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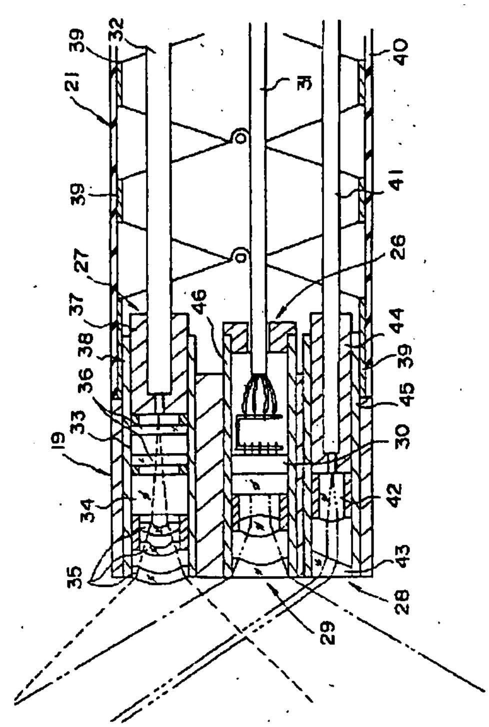
(54)【発明の名称】計測用内視鏡装置

(57)【要約】

【目的】 煩雑なキャリブレーションを必要とせず、立体形状を精度よく、かつ迅速に求めることができる計測用内視鏡装置を提供すること。

【構成】 被検体像を撮像する撮像ユニット２６と、被検体に対して３次元情報を得るための干渉縞を照射する干渉縞投影ユニット２７と、内視鏡の挿入部先端から被検体までの距離を計測するための輝点を投影するレーザスポット投影ユニット２８と、被検体に形成された干渉縞と測距情報に基づいて被検体の３次元情報を演算するコンピュータなどを具備している。



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【特許請求の範囲】

【請求項１】　被検体像を撮像する撮像手段と、

前記被検体に対して干渉縞を照射する干渉縞照射手段と、

内視鏡の挿入部先端から被検体までの距離を測定する測距手段と、

前記測距手段の測距情報に基づいて前記被検体の３次元情報を演算する演算手段と、

を具備したことを特徴とする計測用内視鏡装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、内視鏡の先端から被検体までの距離を測定する測距手段を備えた計測用内視鏡装置に関する。

【０００２】

【従来技術】近年、体腔内に細長の挿入部を挿入することにより体腔内臓器等を観察したり、必要に応じて処置具チャンネル内に挿通した処置具を用いて各種治療処置のできる内視鏡が広く用いられている。また、工業分野においても、ボイラー、タービン、エンジン、化学プラント等の内部のキズ，腐食等の観察、検査に工業用内視鏡が広く用いられている。

【０００３】特開昭５９－６９７２１に、内視鏡先端部に測長用のビーム光を放射する手段が示されている。また、特開昭６２－７３２２３には一本のレーザー光線による測距手段が示されている。特開昭６４－４９５４２に体内の臓器表面等の凹凸を計測する計測内視鏡として、回析格子にによるレーザ光の回析パターンを利用したものが示されている。

【０００４】この回析パターンは投影レンズによって被測定物表面上に投影され、この投影像を視差のある位置から固体撮像素子等の撮像素子で観察すると、ラインあるいはドット状パターンは表面の凹凸形状に応じて変形して見える。そのため、撮像素子の画像信号に基づいて、被測定物表面上のライン状パターンの各明部に関して基準位置からの明度の変位量を演算することにより、物体表面の凹凸形状を計測することができるというものである。また、公知事実として干渉縞を物体表面に投影し、前記干渉縞を走査して測定精度を向上させる手法が有る。

【０００５】

【発明が解決しようとする問題点】特開昭６４－４９５４２はドット状パターンのピッチで計測精度が決まる。精度を向上させるにはピッチを細かくしなければならないが、パターン投影光学系の大きさやパターン照射範囲等を考慮するとピッチ幅に限界があり高精度な計測はできない。

【０００６】これに対して、干渉縞走査方法による形状測定では干渉縞の縞ピッチの約１／５０程度の測定精度が得られるが、基準寸法（物体距離または、物体面上の縞間隔あるいは、既知の形状測定によるキャリブレーション）を入力しなければ３次元形状の絶対値（実寸法）を得ることができない。しかし、一般に内視鏡による形状測定では機械内部の計測が主な目的となるため、あらかじめ物体距離等の基準寸法を知ることができず物体距離の入力や、キャリブレーション等を行うことができない。

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【０００７】本発明は上記事情に鑑みてなされたものであり、煩雑なキャリブレーションを必要とせず、立体形状を精度よく、かつ迅速に求めることができる計測用内視鏡装置を提供することを目的とする。

【０００８】

【問題点を解決する手段および作用】本発明では被検体像を撮像する撮像手段と、被検体に対して干渉縞を照射する干渉縞照射手段と、内視鏡の挿入部先端から被検体までの距離を測定する測距手段と、この測距手段の測距情報に基づいて被検体の３次元情報を演算する演算手段とを具備することにより、測距手段の測距情報と干渉縞に基づいて前記演算手段により被検体の３次元情報を演算で求められるようにして、煩雑なキャリブレーションを必要とせず、立体形状を精度よく求めることができる。

【０００９】

【実施例】以下、図面を参照して本発明の実施例を具体的に説明する。図１ないし図６は本発明の第１実施例に係り、図１は内視鏡装置の全体構成の説明図、図２は内視鏡先端部の断面図、図３は３次元計測の概要図、図４は干渉縞による計測の原理図、図５はレーザスポットによる測距方法の原理図、図６はレーザ光源のブロック図を示す。

【００１０】図１に示すように、本発明の第１実施例の計測用内視鏡装置１は計測用の電子内視鏡２と、この電子内視鏡２が接続される照明用光源３及びカメラコントロールユニット（以下ＣＣＵ）４と、前記ＣＣＵ４に接続され、３次元情報を演算などするコンピュータ５と、コンピュータ５からの画像を表示するモニタ６及び３次元情報を得るための干渉縞を投影すると共に、測距のための輝点を投影するレーザ光源７を備えている。

【００１１】上記電子内視鏡２は、細長の挿入部１１と、この挿入部１１の後端に連設された太幅の操作部１２とを有し、この操作部１２から外部に延出されたユニバーサルケーブル１３の先端に設けられた光源コネクタ１４を照明用光源３に着脱自在で装着することができる。このコネクタ１４から信号ケーブル１５と光ケーブル１６とが延出され、それぞれの端部に設けたコネクタ１７及び１８をそれぞれＣＣＵ４及びレーザ光源７に接続することができる。

【００１２】上記電子内視鏡２の挿入部１１は、その先端に硬質の先端部１９が形成され、この先端部１９に隣接して湾曲自在の湾曲部２１が形成され、さらにこの湾

曲部21の後端に長尺の軟性部22が形成されている。上記湾曲部21は操作部12とに設けた湾曲ノブ23を操作することにより、湾曲できるようになっている。上記コンピュータ5は、キーボード24と接続されている。

【0013】図2は電子内視鏡2の先端部19の断面を示す。電子内視鏡2の先端部19には、被検査物を照明するための図示しないライトガイドファイバ、照明レンズ部、及び画像を得るための撮像ユニット26、物体面に干渉縞を投影する干渉縞投影ユニット27、物体面の干渉縞照明範囲内に輝点を作るためのレーザスポット投影ユニット28が設けられている。

【0014】前記撮像ユニット27は対物レンズ系29及び対物レンズ系29により結像した光学像を電気信号へ変換するための固体撮像素子30及び信号ケーブル31を有する。

【0015】前記干渉縞投影ユニット27は偏波面保存ファイバ32及び偏波面保存ファイバ32の射出光からx軸偏波成分の光とy軸偏波成分の光を分離する為の複屈折光学部材33及び、可干渉波であるx軸偏波とy軸偏波の45°成分を取り出す偏光板34及び、前記可干渉波を物体面に投影する投影レンズ35により構成される。

【0016】尚、図2に示すように複屈折光学部材33は、カバーガラス36，36で両面が保護されている。又、偏波面保存ファイバ32の先端は口金37により、

パイプ38に固着され、このパイプ38は先端部19に固定される。先端部19の後端に湾曲部21を形成する第1の駒39が固着され、この駒39にはさらに次の駒39が回動自在に連結されるという具合にして多数の駒39、39…が回動自在に連結されている。多数の駒39、39…は可撓性のチューブ40で被覆されている。

【0017】前記レーザスポット投影ユニット28は光ファイバ41及び光ファイバ41からの出射光を所定の光束径へ変換する凸レンズ42、及び前記光束を所定の角度で出射するためのプリズム43を有する。上記光ファイバ41の先端は、口金44を介してパイプ45に固着され、このパイプ45は先端部19に固定される。

【0018】尚、撮像ユニット26もパイプ46を介して先端部19に固定されるようになっている。図3は、この電子内視鏡2によって、物体を計測している様子を示す。干渉縞投影ユニット27より干渉縞を物体面48の撮像範囲49内に投影する。この物体面48上に形成された干渉縞照射範囲を符号47で示す。また、前記干渉縞照射範囲47内の一点に、レーザスポット投影ユニット28よりレーザスポットを照射して輝点50をつくる。

【0019】図4、図5に示す原理図をもとに計測方法を説明する。干渉縞投影による形状測定は種々の方法が提案されているが、例えば4バケット法では以下の式により計算される。

【0020】干渉縞の強度分布I(x,y,n)は、

$$I(x,y,n)=Io(x,y)\left[1+\gamma\cos\{2\pi\omega(x,y)+\phi n\}\right] \quad (1)$$

となる。ここで、

Io(x,y)　：　光源の強度分布

γ　：　可視度

ω(x,y)　：　物体光の歪

φn　：　干渉光の初期位相

である。

【0021】初期位相φnを90°づつ変化させ、

$$\phi n=n\pi/2\ (n=0,1,2,3) \quad (2)$$

とすると、

$$I(x,y,1)=Io(x,y)\left[1+\gamma\cos 2\pi\omega(x,y)\right] \quad (3)$$

$$I(x,y,2)=Io(x,y)\left[1-\gamma\sin 2\pi\omega(x,y)\right] \quad (4)$$

$$I(x,y,3)=Io(x,y)\left[1-\gamma\cos 2\pi\omega(x,y)\right] \quad (5)$$

$$I(x,y,4)=Io(x,y)\left[1+\gamma\sin 2\pi\omega(x,y)\right] \quad (6)$$

と表される。

$In=I(x,y,n)$ で表すと

【0022】(3)(4)(5)(6)式より、

$$2\pi\omega(x,y)=\arctan\left[(I4-I2)/(I1-I3)\right] \quad (7)$$

となる。

【0023】ここで物体ω(x,y)は光強度分布の位相ずれと解釈できるから、図4に示すように例えば対物レンズ系29の光軸上における被検体としての物体側に直角座標の原点を設定し、干渉縞を投影する光源の位置、つまり光軸とx軸偏波光源p1とy軸偏波p2光源の中点とのなす角をθとして、この解釈を当てはめると(7)式は、

$$(2\pi/T')\Delta z\ \tan\theta = \arctan[I4-I2)/(I1-I3)] \quad (8)$$

となる。

【0024】ここで、

$$T'=L\lambda/d\ \cos\theta \quad (9)$$

λ　：　レーザの波長

d　：　x軸偏波光源p1とy軸偏波p2光源間の距離

である。

【0025】よって物体における高さΔzは、

$$\Delta z\ (x,y) = (T' / 2\pi \tan\theta) \cdot \arctan[(I4 - I2) / (I1 - I3)] \quad (10)$$

となる。ここで内視鏡先端から物体面までの距離Lをレーザスポット投影ユニット２８を用いて測定する。

【００２６】以降にレーザスポットによる測距方法を示す。図５に示すように物体面のレーザスポットによる輝点をＰ、対物レンズ系２９の中心点をＯ、レーザスポット投影点をＱとする。ｘ’軸とＯ－Ｐのなす角度をβ、ｘ’軸とＱ－Ｐのなす角度をα、Ｏ－Ｑの長さをＨとすると距離Ｌは次式で示される。

【００２７】

$$L = (H * \sin\alpha * \sin\beta) / \{\sin(\beta - \alpha)\} \quad (11)$$

この（１１）式による測長結果を（９）式に代入すれば（１０）式より物体表面の高さΔｚを求めることができる。干渉縞の範囲内の全てのΔｚ (x,y) について同様に計算すれば物体表面３次元形状が得られる。

【００２８】図６はレーザ光源のブロック図を示す。コネクタ１８には干渉縞投影用コネクタ１８ａ及びレーザスポット当投影用光コネクタ１８ｂが設けられている。前記干渉縞投影用光コネクタ１８ａの図示しない偏波面保存光ファイバ端面にはコリメートレンズ５１ａにより半導体レーザ５２ａの光線が集光するように構成されている。前記半導体レーザ５２ａには支持板５３、ペルチェ素子５４を介してヒートシンク５５ａが取り付けられている。

【００２９】また、前記支持板５３には温度検出素子である例えばサーミスタ５６が取り付けられている。前記ペルチェ素子５４及びサーミスタ５６は定温度制御回路５７に接続されており、前記半導体レーザ５２ａを一定の温度に保つように温度制御される。

【００３０】また、前記半導体レーザ５２ａは電流制御回路５８に接続され、所定の電流値で駆動される。前記電流制御回路５８はＤ／Ａコンバータ回路５９を通じてコンピュータ５の信号により任意の電流値へ設定される。

【００３１】半導体レーザ５２ａは駆動電流を変化させると波長がシフトする。前記コンピュータ５により半導体レーザ５２ａの駆動電流を変化させると前記干渉縞投影ユニット２７の干渉光の位相がシフトして、物体上の干渉縞を移動させることができる。

【００３２】レーザスポット投影用光コネクタ１８ｂの図示しない光ファイバ端面にはプリズム６０、コリメートレンズ６１ｂにより半導体レーザ６２ｂの光線が集光するように構成されている。また、前記半導体レーザ６２ｂは放熱のためにヒートシンク６３ｂに取り付けられている。前記半導体レーザ６２ｂは定電流制御回路６４により定電流駆動される。

【００３３】但し、レーザスポット投影用の光源としては、高輝度ＬＥＤ等の発光源を用いてもよい。次に第１実施例による測長方法を以下に説明する。内視鏡先端部１９を被測定物である物体表面に対向させ測定範囲が干渉縞照射範囲内に入るようにセットする。

【００３４】レーザスポット投影ユニット２８からのレーザビームによる物体面上の輝度位置を撮像系を通じて求め（１１）式より距離Ｌを求める。次にコンピュータ５によりレーザ光源７へ信号を送り、干渉縞の位相をπ／４ずつ変化させ４枚の画像をＣＣＵ４内又はコンピュータ５内の図示しないフレームメモリへ取り込む。４枚の画像を（１０）式を用いた演算をコンピュータ５で行うことにより、物体表面の３次元形状が得られる。

【００３５】このように内視鏡的に測距と３次元計測が同時にできるシステムを提供することにより従来分解しなければ精密な計測が不可能であった、例えば曲面形状であるジェットエンジンのタービンブレードのクラック寸法を分解せずに精密に測定することができる。また、水道管等の減肉状態も非破壊的に精密測定できる。

【００３６】また、レーザスポット投影用半導体レーザ６２ｂと干渉縞投影用半導体レーザ５２ａに異なる波長のものを用いてもよい。たとえば、レーザスポット投影用半導体レーザとして青色レーザ、干渉縞投影用半導体レーザとして赤色レーザを用いれば、画像処理より青色レーザスポットにより測距を行い、赤色の干渉縞により３次元計測を自動的に行うことができる。

【００３７】以下、図面を参照して本発明の第２実施例を具体的に説明する。

【００３８】図７は、内視鏡先端部の断面図を示す。第２実施例は第１実施例に示したレーザビームによる測距方法を変更したものである。内視鏡先端部には先端面７０に開口したチャンネル７１を有し、前記チャンネル７１からはゲージ７２が先端方向に挿脱される。

【００３９】前記ゲージ７２には、測距用の目盛り７３が記されており、視野のＢ点より前記目盛り７３を読み取る。前記目盛り７３はＢ点の値が内視鏡先端面７０から物体面までの距離を表すようにあらかじめオフセットして記されていてもよい。読み取った値を距離Ｌとして第１実施例に示す（９）（１０）（１１）式を用いれば物体表面の３次元形状を求めることができる。

【００４０】本実施例によれば測距用のレーザスポット投影ユニット及び光源が不要となるためより安価なシステムを提供できる。尚、測距方法は本実施例に限るものではなく、例えば、照明光と一緒に指標となる影等を投影し、それを基に測距するといったものでもよい。次に第３実施例を説明する。

【００４１】第３実施例はレーザ光源ブロック内に１つのレーザ光源を用いたものである。図８はレーザ光源７のブロック図を示す。半導体レーザ８０の出射光はコリ

メートレンズ８１により平行光線に変換された後、ビームスプリッタ８２により光路８３ａと光路８３ｂに分岐される。光路８３ａの光は集光レンズ８４によりレーザスポット投影用光コネクタ端子８５に集光される。光路８３ｂの光はプリズム８６をへて集光レンズ８７により干渉縞投影用光コネクタ端子８８に集光される。その他の構成及び作用は第１実施例に同じである。

【００４２】前記半導体レーザ８０には支持板５３、ペルチェ素子５４を介してヒートシンク５５ａが取り付けられている。また、前記支持板５３には温度検出素子である例えばサーミスタ５６が取り付けられている。前記ペルチェ素子５４及びサーミスタ５６は定温度制御回路５７に接続されており前記半導体レーザ８０を一定の温度に保つように温度制御される。

【００４３】また、前記半導体レーザ８０は電流制御回路５８に接続され、所定の電流値で駆動される。前記電流制御回路５８はＤ／Ａコンバータ回路５９を通じてコンピュータ５の信号により任意の電流値へ設定される。半導体レーザ８０は駆動電流を変化させると波長がシフトする。

【００４４】前記コンピュータ５により半導体レーザ８０の駆動電流を変化させると前記干渉縞投影ユニットの干渉光の位相がシフトして、物体上の干渉縞を移動させることができる。しかし、同じ半導体レーザ８０の光を用いているレーザスポットは波長がシフトしてもその影響は受けない。

【００４５】また、図９（ａ），（ｂ）に示すように光路８９ｃに可動ミラー９０を設け、光路８９ａ、光路８９ｂを選択可能にしても良い。この第３実施例又はその変形例では一つの半導体レーザ８０で干渉縞とレーザスポットの光源を構成したことにより、より安価なシステムを提供できる。次に第４実施例を説明する。

【００４６】第４実施例は一本の光ファイバを用いて内視鏡先端部にレーザ光を導き、内視鏡先端部内で光路を２分割して、干渉縞照射光学系及びレーザスポット照射系の光源として用いるものである。

【００４７】図１０は内視鏡先端の各光学系の配置を示す。図１１は図１０のＡ－Ａ断面を示す。図１２はレーザ光源の内部を示す。図１２に示すように、電流制御、温度制御された半導体レーザ９２の出射光はコリメートレンズ９３、集光レンズ９４をへて光コネクタ端子９５へ集光される。前記光コネクタ端子９５から入射した光は、図１１に示すように光ファイバ９６を通じて内視鏡先端部へ伝達される。内視鏡先端部に伝達されたレーザ光はコリメートレンズ９７により平行光線に変換された後ビームスプリッタ９８により光路が２分割される。

【００４８】前記ビームスプリッタ９８を直進したレーザ光は光軸９９ａを経て干渉縞照射光学系１０１に入り、複屈折光学部材３３、偏光板３４、投影レンズ３５等を経て物体表面に干渉縞が投影される。前記ビームスプリッタ９８により分岐したレーザ光は９０°方向を変え、光路を経てレーザスポット照射光学系１０２に入り、プリズム１０３により内視鏡の軸方向に変換され、凸レンズ１０４、凹レンズ１０５によりビーム径が絞られた細径ビーム１０６にされた後にプリズム１０７により所定の角度で出射される。

【００４９】図１１において、偏波面を保存するファイバ９６の先端は、口金１０８によりパイプ１０９に固着される。又、プリズム１０３等のレーザスポット照射光学系１０２はパイプ１１０に固着されている。図１０において、対物レンズ系１１１の両側に、照明光学系１１２，１１２が設けてある。その他の構成は、第３実施例と同様である。

【００５０】このように１本の光ファイバ９６からの出射光を干渉縞照射及びレーザスポット照射用いたことにより高価な光ファイバ９６の使用量が半減するため低価格な計測用内視鏡を提供できる。

【００５１】次に本発明の第５実施例を具体的に説明する。図１３ないし図１８は本発明の第５実施例に係り、図１３は内視鏡装置の全体構成の説明図、図１４は内視鏡先端部の断面図、図１５はレーザ光源のブロック図、図１６はコンピュータのブロック図、図１７はピエゾ素子の駆動電圧（ＤＣ－ＡＭＰ出力電圧）と各フレームメモリのフリーズのタイミングを示すタイミングチャート図、図１８は物体面に投影されている干渉縞の位相の変化を示す説明図である。

【００５２】図１３に示すように、本発明の第５実施例の計測用内視鏡装置２０１は計測用の電子内視鏡２０２と、この電子内視鏡２０２が接続される照明用光源２０３及びＣＣＵ２０４と、前記ＣＣＵ２０４に接続されるコンピュータ２０５と、コンピュータ２０５からの画像を表示するモニタ２０６及びレーザ光源２０７を備えている。

【００５３】上記電子内視鏡２０２は、細長の挿入部２１１と、この挿入部２１１の後端に連設された太幅の操作部２１２とを有し、この操作部２１２から外部に延出されたユニバーサルケーブル２１３の先端に設けられた光源コネクタ２１４を照明用光源２０３に着脱自在で装着することができる。このコネクタ２１４から信号ケーブル２１５と光ケーブル２１６とが延出され、それぞれの端部に設けたコネクタ２１７及び２１８をそれぞれＣＣＵ２０４及びレーザ光源２０７に接続することができる。

【００５４】上記電子内視鏡２０２の挿入部２１１は、その先端に硬質の先端部２１９が形成され、この先端部２１９に隣接して湾曲自在の湾曲部２２１が形成され、さらにこの湾曲部２２１の後端に長尺の軟性部２２２が形成されている。上記湾曲部２２１は操作部２１２とに設けた湾曲ノブ２２３を操作することにより、湾曲できるようになっている。上記コンピュータ２０５は、キー

ボード２２４と接続されている。

【００５５】図１４は電子内視鏡２０２の先端部２１９の断面を示す。電子内視鏡２０２の先端部２１９には、被検査物を照明するための図示しないライトガイドファイバ、照明レンズ部、及び画像を得るための撮像ユニット２２６、物体面に干渉縞を投影する干渉縞投影ユニット２２７、物体面の干渉縞照明範囲内に輝点を作るためのレーザスポット投影ユニット２２８が設けられている。上記撮像ユニット２２６は対物レンズ系２２９及び対物レンズ系２２９により結像した光学像を電気信号へ変換するための固体撮像素子２３０及び信号ケーブル２３１を有する。

【００５６】上記干渉縞投影ユニット２２７はシングルモードファイバ２３２及び口金２３３で先端が固定されたこのシングルモードファイバ２３２の射出光を平行光にするコリメートレンズ２３４と、この平行光から互いに直交する２つの偏波成分の光に分離して出力する偏光ビームスプリッタ２３５と、該偏光ビームスプリッタ２３５を経た光を投影する投影レンズ２３６と、前記一方の偏波成分の光を他方の偏波成分の光に対して光路差を与えるためのミラー２３７、２３８と、一方のミラー２３７を該ミラー２３７面に垂直な方向に変位させるためのピエゾ素子２３９とを有する。

【００５７】上記投影レンズ２３６、ミラー２３８、ミラー２３７の裏面に形成された蒸着などで形成された反射面２３７ａに取り付けられたピエゾ素子２３９はホルダ２４１を介して先端部２１９に取り付けられている。なお、ミラー２３８の裏面にも蒸着などで反射面２３８ａが形成されている。上記２つのミラー２３７、２３８は偏光ビームスプリッタ２３５の上下両側に配置され、ミラー２３７は偏光ビームスプリッタ２３５と距離（例えばMとする）隔てて配置され、他方のミラー２３８は偏光ビームスプリッタ２３５の上面に接して配置され、例えばその厚さがNである。

【００５８】上記ピエゾ素子２３９の両面には電極が取り付けられ、各電極にはリード線２４２の先端と接続され、図示しない駆動回路からピエゾ素子２３９を駆動して、ミラー２３７の位置を上下方向に変位させることができるようになっている。

【００５９】上記コリメートレンズ２３４を経た平行光は偏光ビームスプリッタ２３５を透過して光路Ａに沿って進む光成分と、偏光ビームスプリッタ２３５で反射され、第１のミラー２３７で反射され、偏光ビームスプリッタ２３５を透過し、第２のミラー２３８で反射され、さらに偏光ビームスプリッタ２３５で反射されて光路Ｂのように進む光成分とに分離され、光路Ａに沿って進む光に対し、光路Ｂに沿って進む光は、偏光ビームスプリッタ２３５の上下方向の厚み（長さ）をＬとすると、２（ｒＬ＋ｓＭ＋Ｎ）（ｒ，ｓは偏光ビームスプリッタ２３５、ミラー２３８の屈折率）だけ大きい光路長（光路差）Ｄが与えられた後、共に投影レンズ２３６を経て被写体（物体面）側に投影される。

【００６０】そして被写体側には光路差Ｄに応じて図３で示したような干渉縞が形成されることになり、さらに上記ピエゾ素子２３９を駆動して、ミラー２３７の位置を上下方向に変位させることにより、この光路差Ｄから微小光路差ΔＤだけ変位させることができるようになっている。この微小光路差ΔＤだけ変位させることにより、干渉縞がシフトし、４バケット法で物体面の３次元形状を求めることができるようにしている。

【００６１】上記レーザスポット投影ユニット２２８は光ファイバ２４４及び光ファイバ２４４からの出射光を所定の光束径へ変換する凸レンズ２４５、及び前記光束を所定の角度で出射するためのプリズム２４６を有する。上記光ファイバ２４４の先端は、口金２４７を介してパイプ２４８に固着され、このパイプ２４８は先端部２１９に固定される。

【００６２】図１５はレーザ光源２０７のブロック図を示す。半導体レーザ８０の出射光はコリメートレンズ８１により平行光線に変換された後、ビームスプリッタ８２により光路８３ａと光路８３ｂに分岐される。光路８３ａの光は集光レンズ８４によりレーザスポット投影用光コネクタ端子８５に集光される。又、半導体レーザ８０は定電流制御回路２５８により駆動される。この定電流制御回路２５８はＤ／Ａコンバータ回路５９を通じてコンピュータ２０５によって制御され、干渉縞を適切な光量に保つ。その他の構成は図８に示す第３実施例のレーザ光源７と同じである。

【００６３】一方、上記コンピュータ２０５の内部構成を図１６に示す。上記ＣＣＵ２０４からの画像信号はフレームメモリ部２５１を構成するフレームメモリＡ，Ｂ，Ｃ，Ｄに入力され、（ＣＰＵ＆メモリ２５２）のＣＰＵからの信号により任意のタイミングでフリーズできる。又、内視鏡先端部２１９の干渉縞投影ユニット２２７に組み込まれたピエゾ素子２３９の変位はＣＰＵによりＤ／Ａコンバータ２５３、ＤＣ－ＡＭＰ２５４を通じて電圧で制御される。

【００６４】つまり、コンピュータ２０５からピエゾ素子２３９の変位を制御することにより、上記光路Ａと光路Ｂの光路差Ｄから微小光路差ΔＤを変え、干渉縞の位相を任意に設定できる。そして、ＣＰＵによる演算結果はグラフィックボード２５５を通じてモニタ２０６に表示される。

【００６５】上記ピエゾ素子２３９への駆動電圧とフレームメモリＡ，Ｂ，Ｃ，Ｄのフリーズのタイミングを図１７に示す。この図１７に示すように、ピエゾ素子２３９に印加されるＤＣ－ＡＭＰ２５４の出力電圧は階段状に変化させ、物体面に投影される干渉縞の位相（Ｐｈａｓｅ）が９０°毎に変化するように、つまり図１８に示すようにＰｈａｓｅ　Ａ，Ｂ，Ｃ，Ｄが９０°毎に変化

するようにＤＣ－ＡＭＰ２５４の出力電圧を決定する。

【００６６】又、物体面に投影される干渉縞の各位相が安定した状態で図１６に示すようにそれぞれフレームメモリＡ，Ｂ，Ｃ，Ｄにフリーズ画像を記憶するフリーズ信号を発生するようにする。このようにピエゾ素子２３９への駆動電圧を段階状に変化させ、物体面上の干渉縞の位相を９０°毎に変化させ、各位相毎の画像を４枚フレームメモリＡ，Ｂ，Ｃ，Ｄに取り込み、ＣＰＵで演算処理が行われることにより立体形状が求められる。この演算方法は第１実施例と同じである。尚、この実施例のピエゾ素子２３９の代わりにＳＭＡなどのアクチュエータを用いても良い。

【００６７】

【発明の効果】内視鏡先端部に干渉縞照射手段及びスポット光線照射手段を設け、物体面に干渉縞を投影すると共にスポット光線を照射し干渉縞照射範囲内に輝点を少なくとも１点作り、前記輝点の位置から内視鏡先端から物体面までの距離を求め、干渉縞投影による３次元測定の演算において前記距離を用いることにより３次元形状の絶対値を求めることができる。

【図面の簡単な説明】

【図１】本発明の第１実施例の計測用内視鏡装置の全体構成図。

【図２】内視鏡先端部の断面図。

【図３】３次元計測の概要図。

【図４】干渉縞による計測の原理図。

【図５】レーザスポットによる測距方法の原理図。

【図６】レーザ光源のブロック図。

【図７】本発明の第２実施例における内視鏡先端部の断面図。

【図８】本発明の第３実施例におけるレーザ光源のブロック図。

【図９】第３実施例の変形例におけるレーザ光源の一部の構成図。

【図１０】本発明の第４実施例における内視鏡先端の各光学系の配置を示す正面図。

【図１１】図１０のＡ－Ａ断面を示す断面図。

【図１２】第４実施例におけるレーザ光源の内部を示す構成図。

【図１３】本発明の第５実施例の計測用内視鏡装置の全体構成図。

【図１４】第５実施例における内視鏡先端部の断面図。

【図１５】レーザ光源のブロック図。

【図１６】コンピュータのブロック図。

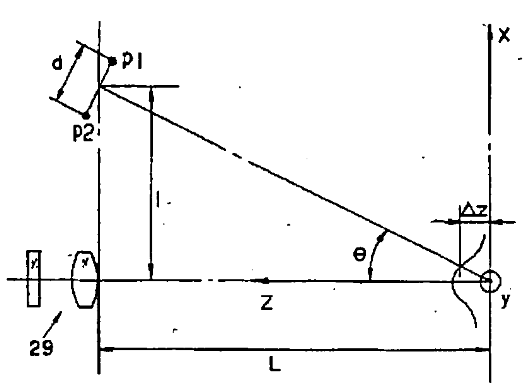
【図１７】ピエゾ素子への駆動電圧と４枚のフレームメモリへのフリーズのタイミングを示す説明図。

【図１８】物体面に投影される干渉縞の４つの位相の関係を示す説明図。

【符号の説明】

１…計測用内視鏡装置
２…電子内視鏡
３…照明用光源
４…ＣＣＵ
５…コンピュータ
６…モニタ
７…レーザ光源
１１…挿入部
１９…先端部
２６…撮像ユニット
２７…干渉縞投影ユニット
２８…レーザスポット投影ユニット
２９…対物レンズ系
３０…固体撮像素子
３２…偏波面保存ファイバ
３３…複屈折光学部材
３４…偏光板
３５…投影レンズ
４１…光ファイバ
４２…凸レンズ
４３…プリズム

【図４】



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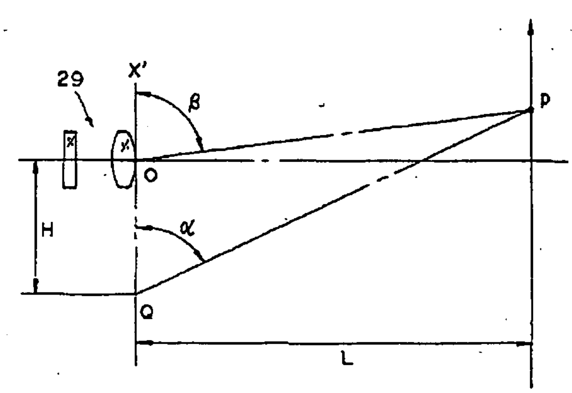

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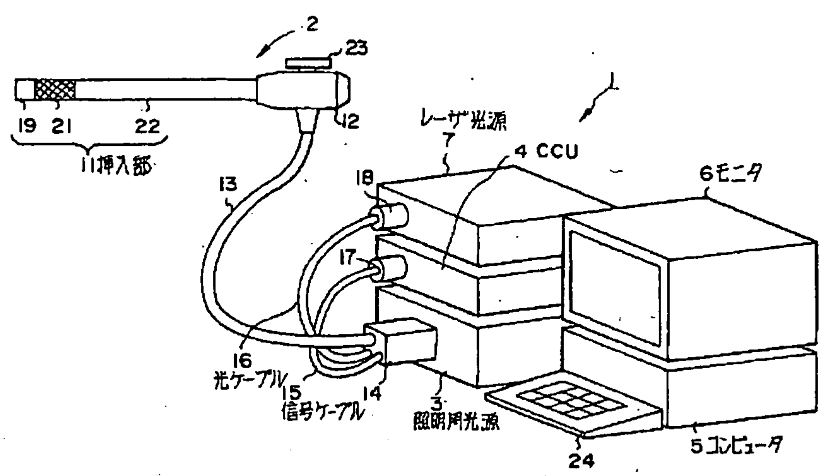

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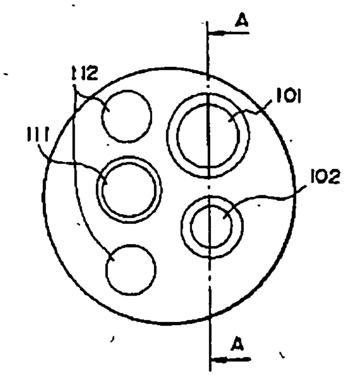

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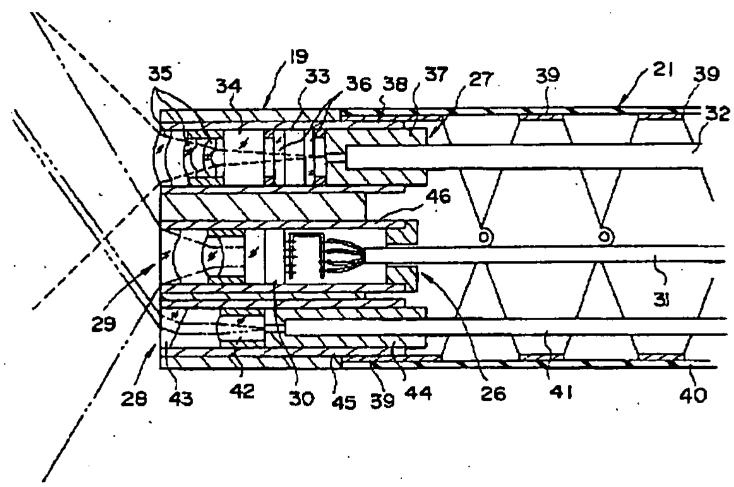

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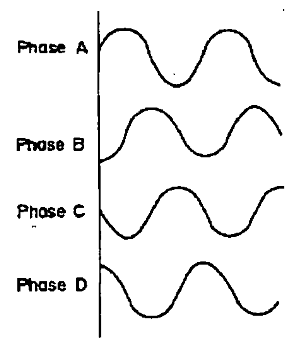

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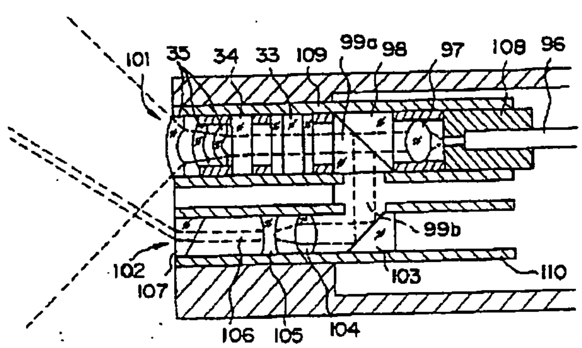

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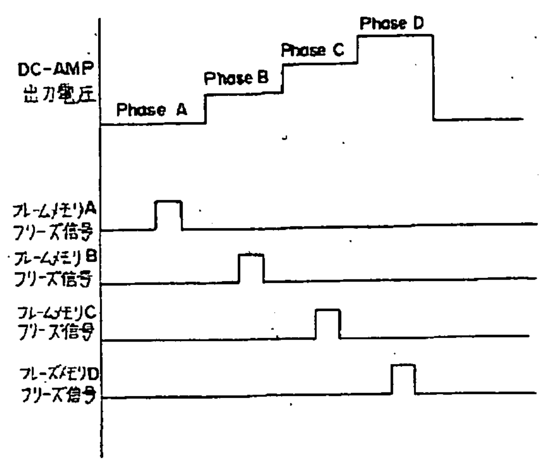

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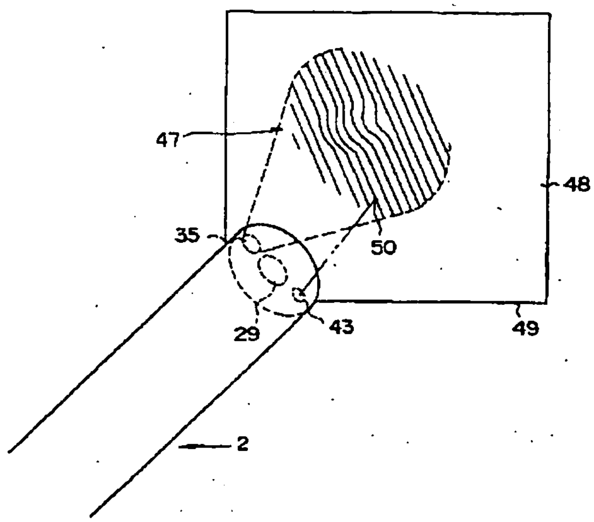
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29
43
49
2

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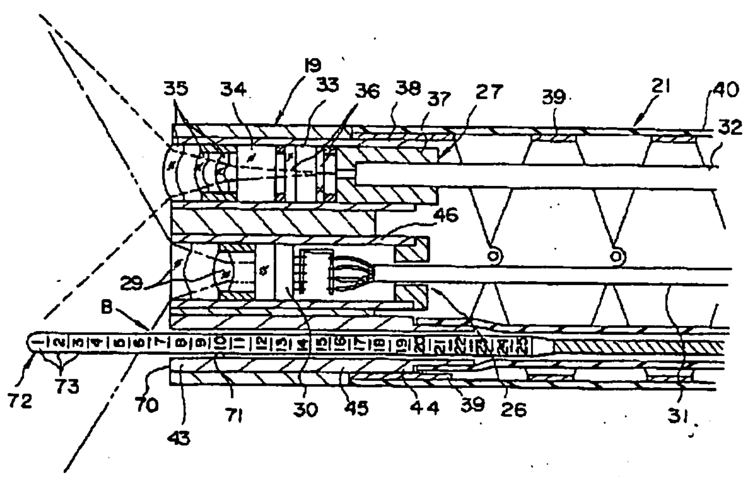
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39
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44
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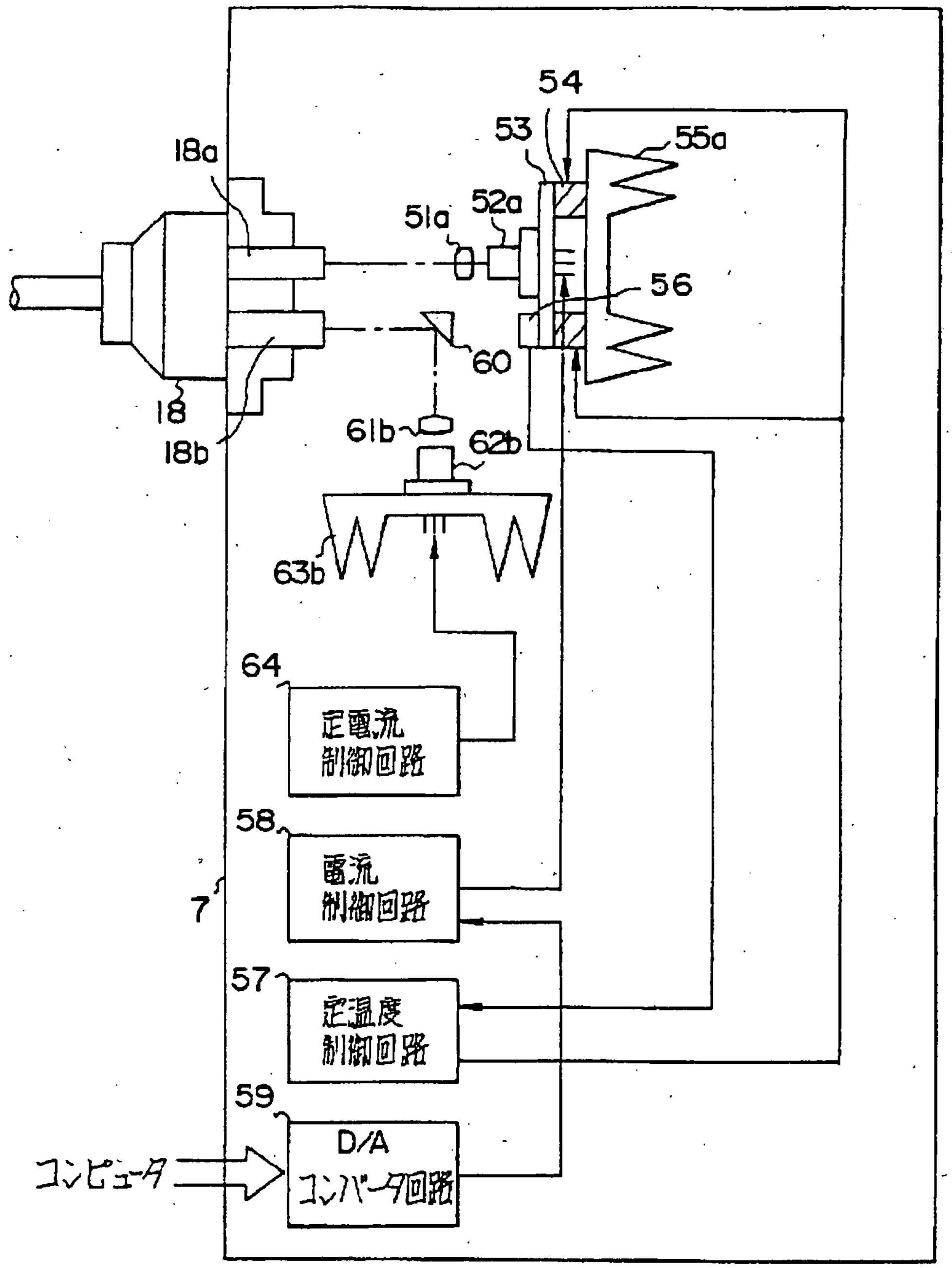
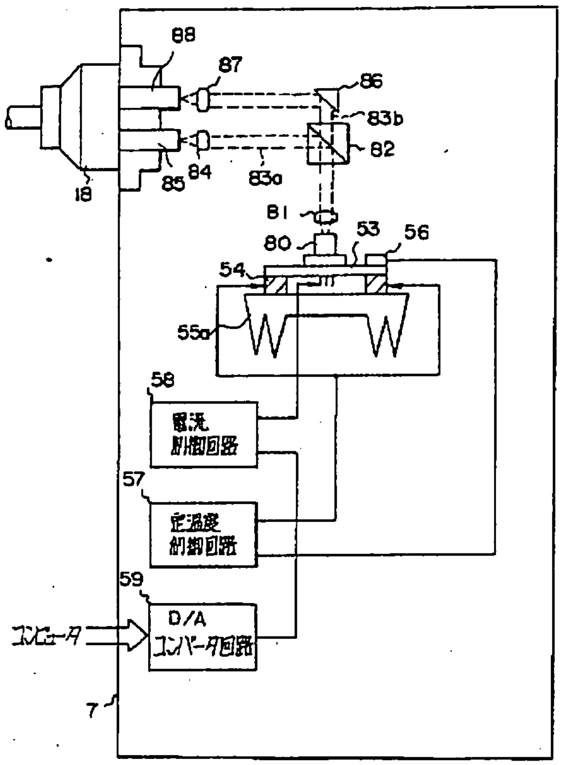
26
31

【図６】


54
53
55a
18a
52a
51a
56
60
18
18b
61b
62b
63b
64
定電流
制御回路
58
電流
制御回路
7
57
定温度
制御回路
59
D/A
コンバータ回路
コンピュータ

【図8】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86
83b
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83a
85
18
81
80
53
56
54
55a
58
電流
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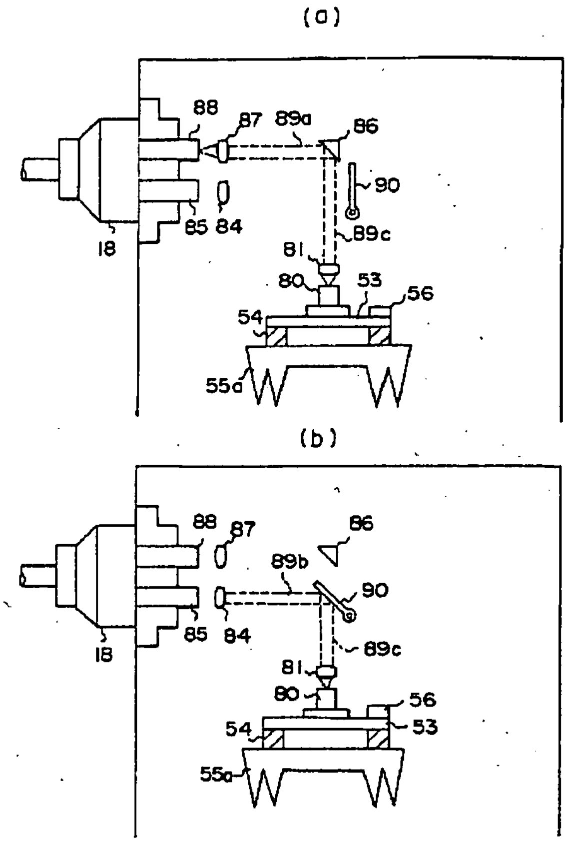
57
定温度
制御回路
59
D/A
コンバータ回路
コンピュータ
7

【図9】


(a)
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89a
86
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85
84
89c
18
81
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53
56
54
55a
(b)
88
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89b
90
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89c
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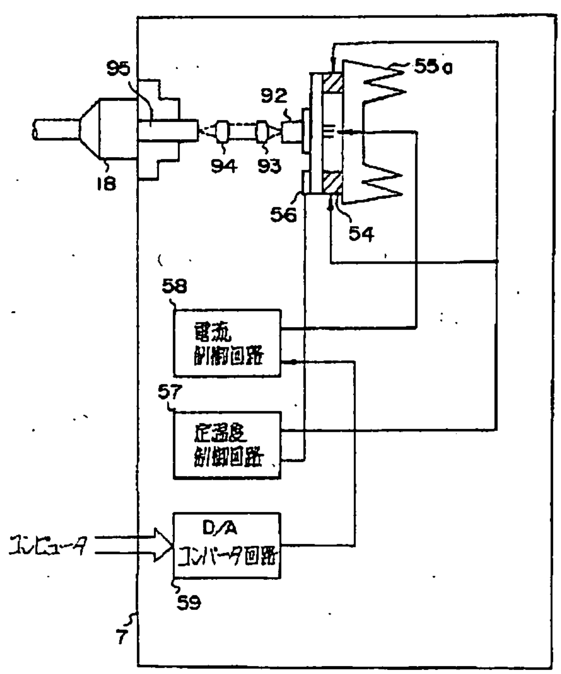
81
80
56
53
54
55a

【図12】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94
93
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54
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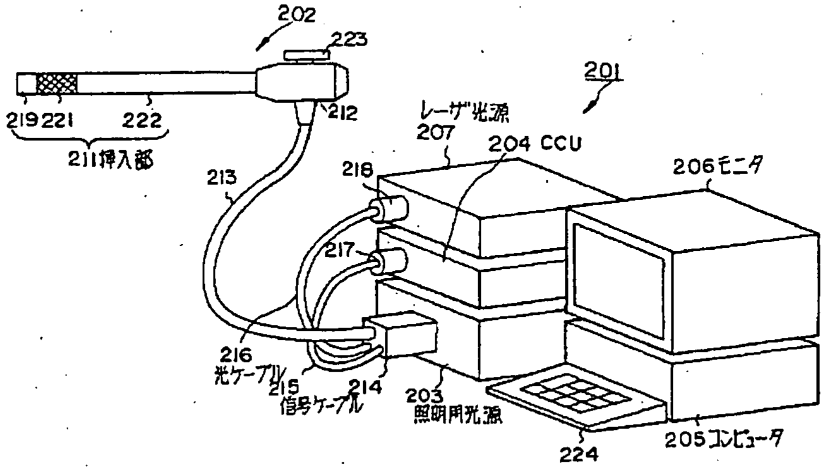
D/A
コンバータ回路
コンピュータ
59
7

【図13】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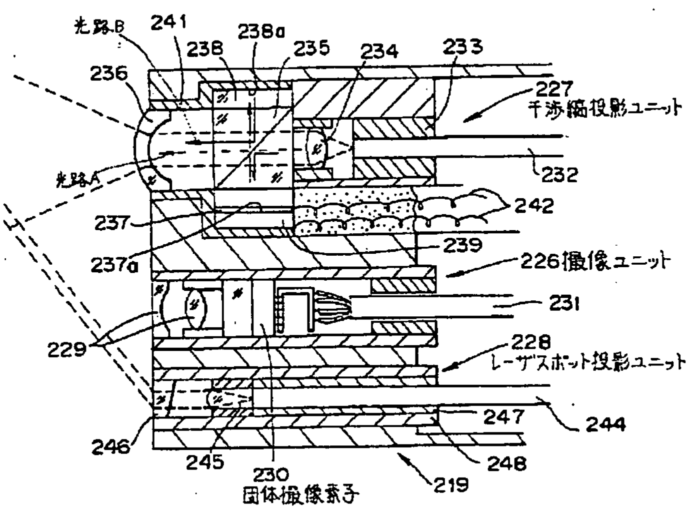
207
204 CCU
206モニタ
213
218
217
216
光ケーブル
215
信号ケーブル
214
203
照明用光源
224
205コンピュータ

【図14】


光路B
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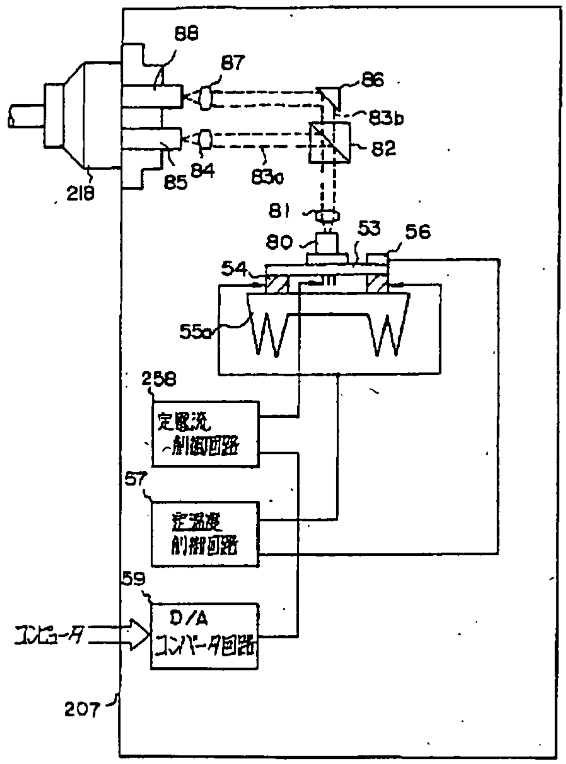
238
238a
235
234
233
236
227
干渉縞投影ユニット
232
光路A
242
237
239
237a
226撮像ユニット
231
229
228
レーザスポット投影ユニット
247
244
246
245
230
固体撮像素子
219
248

【図15】



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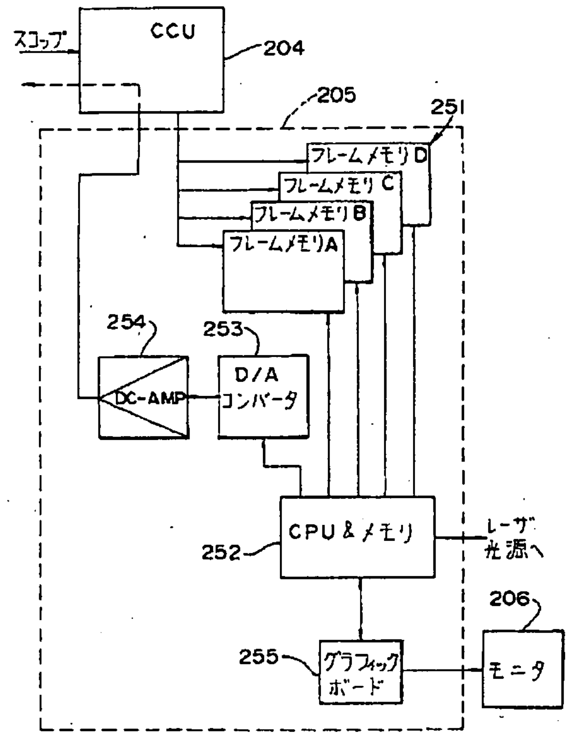

フロントページの続き

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JP05-211928A

* NOTICES *

CLAIMS

[Claim(s)]

[Claim 1] Endoscope equipment for instrumentation characterized by providing an image pck-up means to picturize an analyte image, an interference fringe irradiation means to irradiate an interference fringe to the aforementioned analyte, a ranging means to measure the distance from the insertion section nose of cam of an endoscope to an analyte, and an operation means to calculate the 3-dimensional information on the aforementioned analyte based on the ranging information on the aforementioned ranging means.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] this invention relates to the endoscope equipment for instrumentation equipped with a ranging means to measure the distance from the nose of cam of an endoscope to an analyte.
[0002]
[Description of the Prior Art] By inserting the insertion section of ** length into a coelome in recent years, a coelome viscus machine etc. is observed or the endoscope to which various treatment treatment is made using the treatment implement inserted in in the treatment implement channel if needed is used widely. Moreover, also in the industrial field, the industrial-use endoscope is widely used for observation of the crack of the interior, such as a boiler, a turbine, an engine, and a chemical processing plant, the cauterization, etc., and the check.
[0003] A means to emit the beam light for length measurement to JP,59-69721,A at an endoscope point is shown. Moreover, the ranging means by one laser beam is shown in JP,62-73223,A. the thing using the diffraction pattern of a laser beam boiled and twisted in a diffraction grid as an instrumentation endoscope which measures the irregularity on the front face in the living body of internal organs etc. to JP,64-49542,A is shown
[0004] This diffraction pattern is projected on a device-under-test front face with a projection lens, and when this projection image is observed with image pck-up elements, such as a solid state image pickup device, from the position with parallax, according to the shape of a surface toothing, a line or a dot-like pattern deforms and it appears. Therefore, the shape of a toothing on the front face of a body is measurable by calculating the amount of displacement of the lightness from a criteria position about each bright section of the line-like pattern on a device-under-test front face based on the picture signal of an image pck-up element. Moreover, there is the technique of projecting an interference fringe on a body front face, scanning the aforementioned interference fringe, and raising the accuracy of measurement as a well-known fact.
[0005]
[Problem(s) to be Solved by the Invention] As for JP,64-49542,A, instrumentation precision is decided by the pitch of a dot-like pattern. Although a pitch must be made fine for raising precision, if a size, a pattern irradiation domain, etc. of a pattern projection optical system are taken into consideration, a limitation will be in pitch width of face, and highly precise instrumentation cannot be performed.
[0006] On the other hand, although about 1 / about 50 accuracy of measurement of the striped pitch of an interference fringe is obtained in the configuration measurement by the interference fringe scanning method, if a module (calibration by the fringe spacing on the object distance or a body side or known configuration measurement) is not inputted, the absolute value (actual size) of a 3-dimensional configuration cannot be obtained. However, generally, by the configuration measurement by the endoscope, since the instrumentation inside a machine serves as the main purposes, modules, such as the object distance, cannot be known beforehand and neither the input of the object distance nor a calibration can be

performed.
[0007] this invention is made in view of the above-mentioned situation, and does not need a complicated calibration, but it aims at offering the endoscope equipment for instrumentation which can search for a solid configuration often [precision] and quickly.
[0008]
[The means and operation] which solve a trouble An image pck-up means to picturize an analyte image in this invention, and an interference fringe irradiation means to irradiate an interference fringe to an analyte, By providing a ranging means to measure the distance from the insertion section nose of cam of an endoscope to an analyte, and an operation means to calculate the 3-dimensional information on an analyte based on the ranging information on this ranging means As the 3-dimensional information on an analyte is searched for by the operation by the aforementioned operation means based on the ranging information and interference fringe of a ranging means, a complicated calibration is not needed but a solid configuration can be searched for with a sufficient precision.
[0009]
[Example] Hereafter, with reference to a drawing, the example of this invention is explained concretely. The principle view [accord / the cross section of an endoscope point and the drawing 3] of instrumentation / the schematic diagram of 3-dimensional instrumentation / according / apply the drawing 1 or the drawing 6 to the 1st example of this invention, and / drawing / 1 / drawing 4 / to an interference fringe in explanatory drawing of the whole configuration of endoscope equipment and the drawing 2 , the principle view of the ranging technique according / drawing 5 / to a laser spot, and the drawing 6 show the block diagram of a laser light source
[0010] As shown in drawing 1 , the electronic endoscope 2 for instrumentation in the endoscope equipment for instrumentation 1 of the 1st example of this invention, The light source for a lighting 3 to which this electronic endoscope 2 is connected, and the camera control unit 4 (following CCU), It connects with aforementioned CCU4, and while the interference fringe for acquiring the monitor 6 and 3-dimensional information which display the picture image from the computer 5 by which an operation etc. carries out a 3-dimensional information, and the computer 5 is projected, it has the laser light source 7 which projects the luminescent spot for ranging.
[0011] It can detach [connector / light source / 14 / which was prepared at the nose of cam of the universal cable 13 which the above-mentioned electronic endoscope 2 has the insertion section 11 of ** length, and the control unit 12 of **** formed successively by the back end of this insertion section 11, and extended outside from this control unit 12] freely to the light source for a lighting 3, and can equip. A signal cable 15 and the optical cable 16 can extend from this connector 14, and the connectors 17 and 18 prepared in each edge can be connected to CCU4 and the laser light source 7, respectively.
[0012] The hard point 19 is formed at the nose of cam, the insertion section 11 of the above-mentioned electronic endoscope 2 adjoins this point 19, the bend 21 which can curve freely is formed, and the long elasticity section 22 is further formed in the back end of this bend 21. The above-mentioned bend 21 can curve now by operating the curve knob 23 prepared in the control unit 12. The above-mentioned computer 5 is connected with the keyboard 24.
[0013] Drawing 2 shows the cross section of the point 19 of the electronic endoscope 2. The laser spot projection unit 28 for making the luminescent spot is formed in interference fringe lighting within the limits of the image pck-up unit 26 for acquiring the light-guide fiber not to illustrate, the lighting lens section, and the picture image for illuminating an inspected object in the point 19 of the electronic endoscope 2, the interference fringe projection unit 27 which projects an interference fringe on a body side, and a body side.
[0014] The aforementioned image pck-up unit 27 has the solid state image pickup device 30 and the signal cable 31 for changing into an electrical signal the optical image which carried out image formation by the objective lens system 29 and the objective lens system 29.
[0015] The aforementioned interference fringe projection unit 27 is constituted by the polarizing plate 34 which takes out 45 degree component of x shaft polarization and y-axis

polarization which is the birefringence optical member 33 and good interference wave for separating the light of x shaft polarization component, and the light of a y-axis polarization component from the injection light of the plane-of-polarization store fiber 32 and the plane-of-polarization store fiber 32, and the projection lens 35 which projects the aforementioned good interference wave on a body side.

[0016] In addition, as shown in drawing 2 , as for the birefringence optical member 33, both sides are protected with cover glass 36 and 36. Moreover, the nose of cam of the plane-of-polarization store fiber 32 fixes to a pipe 38 with a mouthpiece 37, and this pipe 38 is fixed to a point 19. 1st ** 39 which forms a bend 21 fixes, it is made the condition of connecting with this ** 39 still free [rotation of next ** 39], and much **s 39 and 39 -- are connected with the back end of a point 19 free [rotation]. Much **s 39 and 39 -- are covered with the flexible tube 40.

[0017] The aforementioned laser spot projection unit 28 has the prism 43 for carrying out the outgoing radiation of the convex lens 42 which changes the outgoing-radiation light from the optical fiber 41 and the optical fiber 41 into the predetermined diameter of the flux of light, and the aforementioned flux of light at an angle of predetermined. The nose of cam of the above-mentioned optical fiber 41 fixes to a pipe 45 through a mouthpiece 44, and this pipe 45 is fixed to a point 19.

[0018] In addition, the image pck-up unit 26 is also fixed to a point 19 through a pipe 46. Drawing 3 shows a mode that the body is measured, with this electronic endoscope 2. An interference fringe is projected into the image pck-up domain 49 of the body side 48 from the interference fringe projection unit 27. A sign 47 shows the interference fringe irradiation domain formed on this body side 48. Moreover, to one in the aforementioned interference fringe irradiation domain 47, from the laser spot projection unit 28, a laser spot is irradiated and the luminescent spot 50 is built.

[0019] The instrumentation technique is explained on the basis of the principle view showing in drawing 4 and the drawing 5 . The configuration measurement by interference fringe projection is calculated by the following formulas, for example by the 4 bucket method, although various technique is proposed.

[0020] Intensity-distribution I (x, y, and n) of an interference fringe is I(x, y, and n) =Io [(x and y)1+gammacos[piomega(x and y)+phi2 n]] (1).

It becomes. Here, it is Io. (x and y) : Intensity-distribution gamma of the light source : Visibility omega (x and y) : Distortion phin of body light : It is the initial phase of an interference light.

[0021] Initial-phase phin It changes 90 degrees at a time. phin =npi/2 (n= 0, 1, 2, 3) (2)

When it carries out, it is. I(x and y1) =Io [(x and y)1 +gammacos2piomega (x and y)] (3)

I(x and y2) =Io [(x and y)1 -gammasin2piomega (x and y)] (4)

I(x and y3) =Io [(x and y)1 -gammacos2piomega (x and y)] (5)

I(x and y4) =Io [(x and y)1 +gammasin2piomega (x and y)] (6)

It is expressed.

[0022] If expressed with In =I (x, y, and n) from (3), (4), (5), and (6) formula 2piomega(x and y) =arctan [(I4-I2)/(I1-I3)] (7)

It becomes.

[0023] Since body omega (x and y) can be interpreted as the phase shift of optical intensity distribution, here As shown in drawing 4 , the zero of rectangular coordinates is set to the body side as an analyte on the optical axis of the objective lens system 29. The position, i.e., an optical axis, x shaft polarization light source pl, and y-axis polarization p2, of the light source which projects an interference fringe They are (7) formulas if this interpretation is applied, using the angle with the middle point of the light source to make as theta. (2pi/T') deltaz tantheta = arctan [I4-I2/(I1-I3)] (8)

It becomes.

[0024] It is here. T'=Llambda/d costheta (9)

lambda : Wavelength d of laser : x shaft polarization light source pl and y-axis polarization p2 It is the distance between the light sources.

[0025] Therefore, height deltaz in a body, deltaz(x and y) =(T'/2pitantheta) - arctan [(I4-I2)/

([1-[3)] (10)
It becomes. Distance L from an endoscope nose of cam to a body side is measured here using the laser spot projection unit 28.
[0026] The ranging technique by the laser spot is shown henceforth. As shown in drawing 5, O and the point projecting [laser spot] are set [the luminescent spot by the laser spot of a body side] to Q for the central point of P and the objective lens system 29. Distance L is shown by the following formula when the length of alpha and O-Q is set to H for the angle at which beta, and x' shaft and Q-P make the angle which x' shaft and O-P make.
[0027]
L=(H*sinalpha*sinbeta)/[sin (beta-alpha)] (11)
If the length measurement result by this (11) formula is substituted for (9) formulas, height deltaz on the front face of a body can be calculated from (10) formulas. If it calculates similarly about all deltaz within the limits of an interference fringe (x and y), the 3-dimensional configuration of body surface will be acquired.
[0028] Drawing 6 shows the block diagram of a laser light source. Connector 18a for interference fringe projection and laser spot this optical connector 18b for projection are prepared in the connector 18. It is constituted by the plane-of-polarization store optical fiber end face which the aforementioned optical connector 18a for interference fringe projection does not illustrate so that the beam of light of semiconductor laser 52a may condense by collimate lens 51a. Heat sink 55a is attached in the aforementioned semiconductor laser 52a through the support plate 53 and the ******** element 54.
[0029] Moreover, the thermistor 56 which is a temperature sensing element is attached in the aforementioned support plate 53. It connects with the degree control circuit 57 of constant temperature, and the temperature control of the aforementioned ******** element 54 and the thermistor 56 is carried out so that the aforementioned semiconductor laser 52a may be maintained at fixed temperature.
[0030] Moreover, it connects with the current control circuit 58, and the aforementioned semiconductor laser 52a is driven with a predetermined current value. The aforementioned current control circuit 58 is set to arbitrary current values by the signal of a computer 5 through the D/A-converter circuit 59.
[0031] If semiconductor laser 52a changes a drive current, wavelength will shift it. If the drive current of semiconductor laser 52a is changed by aforementioned computer 5, the phase of the interference light of the aforementioned interference fringe projection unit 27 can shift, and the interference fringe on a body can be moved.
[0032] It is constituted by the optical fiber end face which optical connector 18b for laser spot projection does not illustrate so that the beam of light of semiconductor laser 62b may condense by prism 60 and collimate lens 61b. Moreover, the aforementioned semiconductor laser 62b is attached in heat sink 63b for thermolysis. The constant-current drive of the aforementioned semiconductor laser 62b is carried out by the constant-current control circuit 64.
[0033] However, as light source for laser spot projection, you may use the sources of photogenesis, such as high brightness Light Emitting Diode. Next, the length measurement technique by the 1st example is explained below. It sets so that the endoscope point 19 may be made to counter the body front face which is a device under test and measuring range may go into interference fringe irradiation within the limits.
[0034] It asks for the brightness position on the body side by the laser beam from the laser spot projection unit 28 through an image pck-up system, and distance L is calculated from (11) formulas. Next, a signal is sent to a laser light source 7 by computer 5, and it incorporates to the frame memory to which the phase of an interference fringe is changed every [4 / pi/], and the picture image of four sheets is not illustrated in CCU4 or the computer 5. By performing the operation using (10) formulas of the picture image of four sheets by computer 5, the 3-dimensional configuration on the front face of a body is acquired.

[0035] Thus, if it did not decompose conventionally by offering the system which can perform

ranging and 3-dimensional instrumentation simultaneously in endoscope, precise instrumentation was impossible, for example, it can measure precisely, without decomposing the crack dimension of the turbine blade of the jet engine which is a curved-surface configuration. Moreover, **** status, such as a water pipe, can also be measured precisely in un-destroying.

[0036] Moreover, you may use the thing of the wavelength which is different in semiconductor laser 62b for laser spot projection, and semiconductor laser 52a for interference fringe projection. For example, if red laser is used as semiconductor laser for blue laser and interference fringe projection as semiconductor laser for laser spot projection, from an image processing, it can range by the blue laser spot and a red interference fringe can perform 3-dimensional instrumentation automatically.

[0037] Hereafter, with reference to a drawing, the 2nd example of this invention is explained concretely.

[0038] Drawing 7 shows the cross section of an endoscope point. The 2nd example changes the ranging technique by the laser beam shown in the 1st example. It has the channel 71 which carried out opening to the endoscope point at the apical surface 70, and inserts [gage / 72] in the orientation of a nose of cam from the aforementioned channel 71.

[0039] The graduation 73 for ranging is describing on the aforementioned gage 72, and the aforementioned graduation 73 is read from B points of a visual field. It may offset beforehand and the value of B points may be describing that the aforementioned graduation 73 expresses the distance from the endoscope apical surface 70 to a body side. If (9) which sets read value to distance L and is shown in 1st example, (10), and (11) formula is used, the 3-dimensional configuration on the front face of a body can be searched for.

[0040] Since the laser spot projection unit and the light source for ranging become unnecessary according to this example, a cheaper system can be offered. In addition, it is possible for the ranging technique not to restrict to this example, to project the shadow which serves as an index together with lighting light, and to range on the basis of it. Next, the 3rd example is explained.

[0041] The 3rd example uses one laser light source into a laser light source block. Drawing 8 shows the block diagram of a laser light source 7. The outgoing-radiation light of semiconductor laser 80 branches to optical-path 83a and optical-path 83b by the beam splitter 82, after being changed into a parallel ray by the collimate lens 81. The light of optical-path 83a is condensed by the condenser lens 84 by the optical connector terminal for laser spot projection 85. The light of optical-path 83b is condensed by the condenser lens 87 through prism 86 by the optical connector terminal for interference fringe projection 88. Other configurations and operations are the same as that of the 1st example.

[0042] Heat sink 55a is attached in the aforementioned semiconductor laser 80 through the support plate 53 and the ******** element 54. Moreover, the thermistor 56 which is a temperature sensing element is attached in the aforementioned support plate 53. The temperature control of the aforementioned ******** element 54 and the thermistor 56 is carried out so that it may connect with the degree control circuit 57 of constant temperature and the aforementioned semiconductor laser 80 may be maintained at fixed temperature.

[0043] Moreover, it connects with the current control circuit 58, and the aforementioned semiconductor laser 80 is driven with a predetermined current value. The aforementioned current control circuit 58 is set to arbitrary current values by the signal of a computer 5 through the D/A-converter circuit 59. If semiconductor laser 80 changes a drive current, wavelength will shift it.

[0044] If the drive current of semiconductor laser 80 is changed by aforementioned computer 5, the phase of the interference light of the aforementioned interference fringe projection unit can shift, and the interference fringe on a body can be moved. However, even if wavelength shifts the laser spot which uses the light of the same semiconductor laser 80, the influence does not receive.

[0045] Moreover, as shown in drawing 9 (a) and (b), the movable mirror 90 may be formed in optical-path 89c, and you may make selectable optical-path 89a and optical-path 89b. In this

3rd example or its modification, a cheaper system can be offered by having constituted the light source of an interference fringe and a laser spot from one semiconductor laser 80. Next, the 4th example is explained.
[0046] The 4th example leads a laser beam to an endoscope point using one optical fiber, within an endoscope point, divides an optical path into two and uses it as light source of interference fringe irradiation optical system and laser spot illuminating system.
[0047] Drawing 10 shows arrangement of each optical system at the nose of cam of an endoscope. Drawing 11 shows the A-A cross section of drawing 10 . Drawing 12 shows the interior of a laser light source. As shown in drawing 12 , a current control and the outgoing-radiation light of the semiconductor laser 92 by which the temperature control was carried out are condensed through a collimate lens 93 and the condenser lens 94 to the fiber-optic-connector terminal 95. The light which carried out incidence from the aforementioned fiber-optic-connector terminal 95 is transmitted to an endoscope point through an optical fiber 96, as shown in drawing 11 . 2 ****s of optical paths are carried out by the back beam splitter 98 from which the laser beam transmitted to the endoscope point was changed into the parallel ray by the collimate lens 97.
[0048] The laser beam which went the aforementioned beam splitter 98 straight on goes into the interference fringe irradiation optical system 101 through optical-axis 99a, and an interference fringe is projected on a body front face through the birefringence optical member 33, the polarizing plate 34, the projection lens 35, etc. The laser beam which branched by the aforementioned beam splitter 98 changes the orientation of 90 degree, goes into the laser spot irradiation optical system 102 through an optical path, and is changed into the shaft orientations of an endoscope by prism 103, and after making it the diameter beam 106 of thin to which the beam diameter was extracted by the convex lens 104 and the concave lens 105, the outgoing radiation of it is carried out at an angle of predetermined by prism 107.
[0049] In drawing 11 , the nose of cam of a fiber 96 where plane of polarization is saved fixes to a pipe 109 with a mouthpiece 108. Moreover, the laser spot irradiation optical system 102, such as prism 103, fixes to the pipe 110. In drawing 10 , the lighting optical system 112,112 is formed in the both sides of the objective lens system 111. Other configurations are the same as that of the 3rd example.
[0050] thus, the outgoing-radiation light from one optical fiber 96 — **** for interference fringe irradiation and laser spot irradiation — since the amount of the expensive optical fiber 96 used is halved by things, the low cost endoscope for instrumentation can be offered
[0051] Next, the 5th example of this invention is explained concretely. The timing-chart view in which applying the drawing 13 or the drawing 18 to the 5th example of this invention, and the block diagram of a laser light source and the drawing 16 showing the block diagram of a computer, and, as for the cross section of an endoscope point and the drawing 15 , showing the driver voltage (DC-AMP output voltage) of a piezo-electric element and the timing of a frieze of each frame memory for explanatory drawing of the whole configuration of endoscope equipment and the drawing 14 , as for drawing 17 , and the drawing 18 are explanatory drawings showing change of
[0052] As shown in drawing 13 , the endoscope equipment for instrumentation 201 of the 5th example of this invention is equipped with the monitor 206 and the laser light source 207 which display the picture image from the light source for a lighting 203 and CCU204 to which the electronic endoscope 202 and this electronic endoscope 202 for instrumentation are connected, the computer 205 connected to aforementioned CCU204, and the computer 205.
[0053] It can detach [connector / light source / 214 / which was prepared at the nose of cam of the universal cable 213 which the above-mentioned electronic endoscope 202 has the insertion section 211 of ** length, and the control unit 212 of **** formed successively by the back end of this insertion section 211, and extended outside from this control unit 212] freely to the light source for a lighting 203, and can equip. A signal cable 215 and the optical cable 216 can extend from this connector 214, and the connectors 217 and 218 prepared in each edge can be connected to CCU204 and the laser light source 207, respectively.
[0054] The hard point 219 is formed at the nose of cam, the insertion section 211 of the

above-mentioned electronic endoscope 202 adjoins this point 219, the bend 221 which can curve freely is formed, and the long elasticity section 222 is further formed in the back end of this bend 221. The above-mentioned bend 221 can curve now by operating the curve knob 223 prepared in the control unit 212. The above-mentioned computer 205 is connected with the keyboard 224.

[0055] Drawing 14 shows the cross section of the point 219 of the electronic endoscope 202. The laser spot projection unit 228 for making the luminescent spot is formed in interference fringe lighting within the limits of the image pck-up unit 226 for acquiring the light-guide fiber not to illustrate, the lighting lens section, and the picture image for illuminating an inspected object in the point 219 of the electronic endoscope 202, the interference fringe projection unit 227 which projects an interference fringe on a body side, and a body side. The above-mentioned image pck-up unit 226 has the solid state image pickup device 230 and the signal cable 231 for changing into an electrical signal the optical image which carried out image formation by the objective lens system 229 and the objective lens system 229.

[0056] The collimate lens 234 with which the above-mentioned interference fringe projection unit 227 makes parallel light injection light of this single mode fiber 232 to which the nose of cam was fixed with the single mode fiber 232 and the mouthpiece 233, The polarization beam splitter 235 separated and outputted to the light of two polarization components which intersect perpendicularly mutually from this parallel light, The projection lens 236 which projects the light which passed through this polarization beam splitter 235, It has the piezo-electric element 239 for making the variation rate of the mirrors 237 and 238 for giving the optical path difference for the light of aforementioned one polarization component to the light of the polarization component of another side, and one mirror 237 carry out in the orientation perpendicular [237th page of this mirror].

[0057] The piezo-electric element 239 attached in reflector 237a formed by the vacuum evaporationo formed in the rear face of the above-mentioned projection lens 236, the mirror 238, and the mirror 237 is attached in the point 219 through the electrode holder 241. In addition, reflector 238a is formed also in the rear face of a mirror 238 by vacuum evaporationo etc. The two above-mentioned mirrors 237 and 238 are arranged at the vertical both sides of a polarization beam splitter 235, a mirror 237 is distance(for example, referred to as M)-separated from a polarization beam splitter 235, and is arranged, and the mirror 238 of another side is arranged in contact with the top of a polarization beam splitter 235, for example, the thickness is N.

[0058] An electrode is attached in both sides of the above-mentioned piezo-electric element 239, to each electrode, it connects with the nose of cam of lead wire 242, a piezo-electric element 239 is driven from the drive circuit not to illustrate, and the variation rate of the position of a mirror 237 is carried out in the vertical orientation.

[0059] The optical component which the parallel light which passed through the above-mentioned collimate lens 234 penetrates a polarization beam splitter 235, and progresses along with optical-path A, It is reflected by the polarization beam splitter 235, and is reflected by the 1st mirror 237. Penetrate a polarization beam splitter 235 and it is reflected by the 2nd mirror 238. The light which progresses along with optical-path B to the light which is divided into the optical component which is furthermore reflected by the polarization beam splitter 235, and progresses like optical-path B, and progresses along with optical-path A If thickness (length) of the vertical orientation of a polarization beam splitter 235 is set to L After giving optical-path-length (optical path difference) D only with 2 [large] (rL+sM+N) (r and s are the refractive index of a polarization beam splitter 235 and the mirror 238), it is projected on a photographic subject (body side) side through both the projection lenses 236.

[0060] And an interference fringe which was shown in drawing 3 according to optical-path-difference D will be formed in a photographic subject side, the above-mentioned piezo-electric element 239 is driven further, and the variation rate only of the minute optical-path-difference delta D is carried out from this optical-path-difference D by making the variation rate of the position of a mirror 237 carry out in the vertical orientation. An interference fringe shifts and it enables it to search for the 3-dimensional configuration of a body side by the 4

bucket method by carrying out the variation rate only of this minute optical-path-difference delta D.

[0061] The above-mentioned laser spot projection unit 228 has the prism 246 for carrying out the outgoing radiation of the convex lens 245 which changes the outgoing-radiation light from the optical fiber 244 and the optical fiber 244 into the predetermined diameter of the flux of light, and the aforementioned flux of light at an angle of predetermined. The nose of cam of the above-mentioned optical fiber 244 fixes to a pipe 248 through a mouthpiece 247, and this pipe 248 is fixed to a point 219.

[0062] Drawing 15 shows the block diagram of a laser light source 207. The outgoing-radiation light of semiconductor laser 80 branches to optical-path 83a and optical-path 83b by the beam splitter 82, after being changed into a parallel ray by the collimate lens 81. The light of optical-path 83a is condensed by the condenser lens 84 by the optical connector terminal for laser spot projection 85. Moreover, semiconductor laser 80 is driven by the constant-current control circuit 258. This constant-current control circuit 258 is controlled by the computer 205 through the D/A-converter circuit 59, and maintains an interference fringe at the suitable quantity of light. Other configurations are the same as that of the laser light source 7 of the 3rd example shown in drawing 8 .

[0063] On the other hand, the internal configuration of the above-mentioned computer 205 is shown in drawing 16 . The picture signal from above-mentioned CCU204 is inputted into the frame memories A, B, C, and D which constitute the frame memory section 251, and can be frozen to arbitrary timing with the signal from CPU of (the CPU& memory 252). Moreover, the variation rate of the piezo-electric element 239 included in the interference fringe projection unit 227 of the endoscope point 219 is controlled by the voltage by CPU through D/A converter 253 and DC-AMP254.

[0064] That is, by controlling the variation rate of a piezo-electric element 239 from a computer 205, optical-path-difference D to minute optical-path-difference deltaD of the above-mentioned optical-path A and optical-path B is changed, and the phase of an interference fringe can be set up arbitrarily. And the result of an operation by CPU is displayed on a monitor 206 through the graphic board 255.

[0065] The driver voltage to the above-mentioned piezo-electric element 239 and the timing of a frieze of frame memories A, B, C, and D are shown in drawing 17 . The output voltage of DC-AMP254 impressed to a piezo-electric element 239 as shown in this drawing 17 is Phase as it is shown in drawing 18 so that it may be made to change stair-like and the phase (Phase) of the interference fringe projected on a body side may change every 90 degrees that is,. A, B, C, and D determine that the output voltage of DC-AMP254 will change every 90 degrees.

[0066] Moreover, it is made to generate the frieze signal which memorizes a frieze picture image to frame memories A, B, C, and D, respectively as shown in drawing 16 where the Gentlemen phase of the interference fringe projected on a body side is stabilized. Thus, the driver voltage to a piezo-electric element 239 is changed in the shape of a phase, the phase of the interference fringe on a body side is changed every 90 degrees, the picture image for every Gentlemen phase is incorporated to the four sheet frame memories A, B, C, and D, and a solid configuration is searched for by performing data processing by CPU. This operation technique is the same as that of the 1st example. In addition, you may use actuators, such as SMA, instead of the piezo-electric element 239 of this example.

[0067]

[Effect of the Invention] An interference fringe irradiation means and a spot beam-of-light irradiation means are prepared in an endoscope point, while an interference fringe is projected on a body side, a spot beam of light can be irradiated, at least one luminescent spot can be made to interference fringe irradiation within the limits, the distance from an endoscope nose of cam to [from the position of the aforementioned luminescent spot] a body side can be found, and the absolute value of a 3-dimensional configuration can be calculated by using the aforementioned distance in the operation of the 3-dimensional measurement by interference fringe projection.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

Field

[Field of the Invention] this invention relates to the endoscope equipment for instrumentation equipped with a ranging means to measure the distance from the nose of cam of an endoscope to an analyte.

[Translation done.]

Technique

[Description of the Prior Art] By inserting the insertion section of ** length into a coelome in recent years, a coelome viscus machine etc. is observed or the endoscope to which various treatment treatment is made using the treatment implement inserted in in the treatment implement channel if needed is used widely. Moreover, also in the industrial field, the industrial-use endoscope is widely used for observation of the crack of the interior, such as a boiler, a turbine, an engine, and a chemical processing plant, the cauterization, etc., and the check.
[0003] A means to emit the beam light for length measurement to JP,59-69721,A at an endoscope point is shown. Moreover, the ranging means by one laser beam is shown in JP,62-73223,A. the thing using the diffraction pattern of a laser beam boiled and twisted in a diffraction grid as an instrumentation endoscope which measures the irregularity on the front face in the living body of internal organs etc. to JP,64-49542,A is shown
[0004] This diffraction pattern is projected on a device-under-test front face with a projection lens, and when this projection image is observed with image pck-up elements, such as a solid state image pickup device, from the position with parallax, according to the shape of a surface toothing, a line or a dot-like pattern deforms and it appears. Therefore, the shape of a toothing on the front face of a body is measurable by calculating the amount of displacement of the lightness from a criteria position about each bright section of the line-like pattern on a device-under-test front face based on the picture signal of an image pck-up element. Moreover, there is the technique of projecting an interference fringe on a body front face, scanning the aforementioned interference fringe, and raising the accuracy of measurement as a well-known fact.

[Translation done.]

Effect

[Effect of the Invention] An interference fringe irradiation means and a spot beam-of-light irradiation means are prepared in an endoscope point, while an interference fringe is projected on a body side, a spot beam of light can be irradiated, at least one luminescent spot can be made to interference fringe irradiation within the limits, the distance from an endoscope nose of cam to [from the position of the aforementioned luminescent spot] a body side can be found, and the absolute value of a 3-dimensional configuration can be calculated by using the aforementioned distance in the operation of the 3-dimensional measurement by interference fringe projection.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] As for JP,64-49542,A, instrumentation precision is decided by the pitch of a dot-like pattern. Although a pitch must be made fine for raising precision, if a size, a pattern irradiation domain, etc. of a pattern projection optical system are taken into consideration, a limitation will be in pitch width of face, and highly precise instrumentation cannot be performed.

[0006] On the other hand, although about 1 / about 50 accuracy of measurement of the striped pitch of an interference fringe is obtained in the configuration measurement by the interference fringe scanning method, if a module (calibration by the fringe spacing on the object distance or a body side or known configuration measurement) is not inputted, the absolute value (actual size) of a 3-dimensional configuration cannot be obtained. However, generally, by the configuration measurement by the endoscope, since the instrumentation inside a machine serves as the main purposes, modules, such as the object distance, cannot be known beforehand and neither the input of the object distance nor a calibration can be performed.

[0007] this invention is made in view of the above-mentioned situation, and does not need a complicated calibration, but it aims at offering the endoscope equipment for instrumentation which can search for a solid configuration often [precision] and quickly.

[Translation done.]

OPERATION

[The means and operation] which solve a trouble An image pck-up means to picturize an analyte image in this invention, and an interference fringe irradiation means to irradiate an interference fringe to an analyte, By providing a ranging means to measure the distance from the insertion section nose of cam of an endoscope to an analyte, and an operation means to calculate the 3-dimensional information on an analyte based on the ranging information on this ranging means As the 3-dimensional information on an analyte is searched for by the operation by the aforementioned operation means based on the ranging information and interference fringe of a ranging means, a complicated calibration is not needed but a solid configuration can be searched for with a sufficient precision.

[Translation done.]

EXAMPLE

[Example] Hereafter, with reference to a drawing, the example of this invention is explained concretely. The principle view [accord / the cross section of an endoscope point and the drawing 3] of instrumentation / the schematic diagram of 3-dimensional instrumentation / according / apply the drawing 1 or the drawing 6 to the 1st example of this invention, and / drawing / 1 / drawing 4 / to an interference fringe in explanatory drawing of the whole configuration of endoscope equipment and the drawing 2 , the principle view of the ranging technique according / drawing 5 / to a laser spot, and the drawing 6 show the block diagram of a laser light source

[0010] As shown in drawing 1 , the electronic endoscope 2 for instrumentation in the endoscope equipment for instrumentation 1 of the 1st example of this invention, The light source for a lighting 3 to which this electronic endoscope 2 is connected, and the camera control unit 4 (following CCU), It connects with aforementioned CCU4, and while the interference fringe for acquiring the monitor 6 and 3-dimensional information which display the picture image from the computer 5 by which an operation etc. carries out a 3-dimensional information, and the computer 5 is projected, it has the laser light source 7 which projects the luminescent spot for ranging.

[0011] It can detach [connector / light source / 14 / which was prepared at the nose of cam of the universal cable 13 which the above-mentioned electronic endoscope 2 has the insertion section 11 of ** length, and the control unit 12 of **** formed successively by the back end of this insertion section 11, and extended outside from this control unit 12] freely to the light source for a lighting 3, and can equip. A signal cable 15 and the optical cable 16 can extend from this connector 14, and the connectors 17 and 18 prepared in each edge can be connected to CCU4 and the laser light source 7, respectively.

[0012] The hard point 19 is formed at the nose of cam, the insertion section 11 of the above-mentioned electronic endoscope 2 adjoins this point 19, the bend 21 which can curve freely is formed, and the long elasticity section 22 is further formed in the back end of this bend 21. The above-mentioned bend 21 can curve now by operating the curve knob 23 prepared in the control unit 12. The above-mentioned computer 5 is connected with the keyboard 24.

[0013] Drawing 2 shows the cross section of the point 19 of the electronic endoscope 2. The laser spot projection unit 28 for making the luminescent spot is formed in interference fringe lighting within the limits of the image pck-up unit 26 for acquiring the light-guide fiber not to illustrate, the lighting lens section, and the picture image for illuminating an inspected object in the point 19 of the electronic endoscope 2, the interference fringe projection unit 27 which projects an interference fringe on a body side, and a body side.

[0014] The aforementioned image pck-up unit 27 has the solid state image pickup device 30 and the signal cable 31 for changing into an electrical signal the optical image which carried out image formation by the objective lens system 29 and the objective lens system 29.

[0015] The aforementioned interference fringe projection unit 27 is constituted by the polarizing plate 34 which takes out 45 degree component of x shaft polarization and y-axis polarization which is the birefringence optical member 33 and good interference wave for separating the light of x shaft polarization component, and the light of a y-axis polarization component from the injection light of the plane-of-polarization store fiber 32 and the plane-

of-polarization store fiber 32, and the projection lens 35 which projects the aforementioned good interference wave on a body side.
[0016] In addition, as shown in drawing 2 , as for the birefringence optical member 33, both sides are protected with cover glass 36 and 36. Moreover, the nose of cam of the plane-of-polarization store fiber 32 fixes to a pipe 38 with a mouthpiece 37, and this pipe 38 is fixed to a point 19. 1st ** 39 which forms a bend 21 fixes, it is made the condition of connecting with this ** 39 still free [rotation of next ** 39], and much **s 39 and 39 -- are connected with the back end of a point 19 free [rotation]. Much **s 39 and 39 -- are covered with the flexible tube 40.
[0017] The aforementioned laser spot projection unit 28 has the prism 43 for carrying out the outgoing radiation of the convex lens 42 which changes the outgoing-radiation light from the optical fiber 41 and the optical fiber 41 into the predetermined diameter of the flux of light, and the aforementioned flux of light at an angle of predetermined. The nose of cam of the above-mentioned optical fiber 41 fixes to a pipe 45 through a mouthpiece 44, and this pipe 45 is fixed to a point 19.
[0018] In addition, the image pck-up unit 26 is also fixed to a point 19 through a pipe 46. Drawing 3 shows a mode that the body is measured, with this electronic endoscope 2. An interference fringe is projected into the image pck-up domain 49 of the body side 48 from the interference fringe projection unit 27. A sign 47 shows the interference fringe irradiation domain formed on this body side 48. Moreover, to one in the aforementioned interference fringe irradiation domain 47, from the laser spot projection unit 28, a laser spot is irradiated and the luminescent spot 50 is built.
[0019] The instrumentation technique is explained on the basis of the principle view showing in drawing 4 and the drawing 5 . The configuration measurement by interference fringe projection is calculated by the following formulas, for example by the 4 bucket method, although various technique is proposed.
[0020] Intensity-distribution I (x, y, and n) of an interference fringe is I(x, y, and n) =Io [(x and y)1+gammacos[piomega(x and y)+phi2 n]] (1).
It becomes. Here, it is Io. (x and y) : Intensity-distribution gamma of the light source : Visibility omega (x and y) : Distortion phin of body light : It is the initial phase of an interference light.
[0021] Initial-phase phin It changes 90 degrees at a time. phin =npi/2 (n= 0, 1, 2, 3) (2)
When it carries out, it is. I(x and y1) =Io [(x and y)1 +gammacos2piomega (x and y)] (3)
I(x and y2) =Io [(x and y)1 -gammasin2piomega (x and y)] (4)
I(x and y3) =Io [(x and y)1 -gammacos2piomega (x and y)] (5)
I(x and y4) =Io [(x and y)1 +gammasin2piomega (x and y)] (6)
It is expressed.
[0022] If expressed with In =I (x, y, and n) from (3), (4), (5), and (6) formula 2piomega(x and y) =arctan [(I4-I2)/(I1-I3)] (7)
It becomes.
[0023] Since body omega (x and y) can be interpreted as the phase shift of optical intensity distribution, here As shown in drawing 4 , the zero of rectangular coordinates is set to the body side as an analyte on the optical axis of the objective lens system 29. The position, i.e., an optical axis, x shaft polarization light source pl, and y-axis polarization p2, of the light source which projects an interference fringe They are (7) formulas if this interpretation is applied, using the angle with the middle point of the light source to make as theta. (2pi/T') deltaz tantheta = arctan [I4-I2/(I1-I3)] (8)
It becomes.
[0024] It is here. T'=Llambda/d costheta (9)
lambda : Wavelength d of laser : x shaft polarization light source pl and y-axis polarization p2 It is the distance between the light sources.
[0025] Therefore, height deltaz in a body, deltaz(x and y) =(T'/2pitantheta) - arctan [(I4-I2)/(I1-I3)] (10)
It becomes. Distance L from an endoscope nose of cam to a body side is measured here using the laser spot projection unit 28.

[0026] The ranging technique by the laser spot is shown henceforth. As shown in drawing 5 , O and the point projecting [laser spot] are set [the luminescent spot by the laser spot of a body side] to Q for the central point of P and the objective lens system 29. Distance L is shown by the following formula when the length of alpha and O-Q is set to H for the angle at which beta, and x' shaft and Q-P make the angle which x' shaft and O-P make.
[0027]
L=(H*sinalpha*sinbeta)/{sin (beta-alpha)} (11)
If the length measurement result by this (11) formula is substituted for (9) formulas, height deltaz on the front face of a body can be calculated from (10) formulas. If it calculates similarly about all deltaz within the limits of an interference fringe (x and y), the 3-dimensional configuration of body surface will be acquired.
[0028] Drawing 6 shows the block diagram of a laser light source. Connector 18a for interference fringe projection and laser spot this optical connector 18b for projection are prepared in the connector 18. It is constituted by the plane-of-polarization store optical fiber end face which the aforementioned optical connector 18a for interference fringe projection does not illustrate so that the beam of light of semiconductor laser 52a may condense by collimate lens 51a. Heat sink 55a is attached in the aforementioned semiconductor laser 52a through the support plate 53 and the ******** element 54.
[0029] Moreover, the thermistor 56 which is a temperature sensing element is attached in the aforementioned support plate 53. It connects with the degree control circuit 57 of constant temperature, and the temperature control of the aforementioned ******** element 54 and the thermistor 56 is carried out so that the aforementioned semiconductor laser 52a may be maintained at fixed temperature.
[0030] Moreover, it connects with the current control circuit 58, and the aforementioned semiconductor laser 52a is driven with a predetermined current value. The aforementioned current control circuit 58 is set to arbitrary current values by the signal of a computer 5 through the D/A-converter circuit 59.
[0031] If semiconductor laser 52a changes a drive current, wavelength will shift it. If the drive current of semiconductor laser 52a is changed by aforementioned computer 5, the phase of the interference light of the aforementioned interference fringe projection unit 27 can shift, and the interference fringe on a body can be moved.
[0032] It is constituted by the optical fiber end face which optical connector 18b for laser spot projection does not illustrate so that the beam of light of semiconductor laser 62b may condense by prism 60 and collimate lens 61b. Moreover, the aforementioned semiconductor laser 62b is attached in heat sink 63b for thermolysis. The constant-current drive of the aforementioned semiconductor laser 62b is carried out by the constant-current control circuit 64.
[0033] However, as light source for laser spot projection, you may use the sources of photogenesis, such as high brightness Light Emitting Diode. Next, the length measurement technique by the 1st example is explained below. It sets so that the endoscope point 19 may be made to counter the body front face which is a device under test and measuring range may go into interference fringe irradiation within the limits.
[0034] It asks for the brightness position on the body side by the laser beam from the laser spot projection unit 28 through an image pck-up system, and distance L is calculated from (11) formulas. Next, a signal is sent to a laser light source 7 by computer 5, and it incorporates to the frame memory to which the phase of an interference fringe is changed every [4 / pi/], and the picture image of four sheets is not illustrated in CCU4 or the computer 5. By performing the operation using (10) formulas of the picture image of four sheets by computer 5, the 3-dimensional configuration on the front face of a body is acquired.

[0035] Thus, if it did not decompose conventionally by offering the system which can perform ranging and 3-dimensional instrumentation simultaneously in endoscope, precise instrumentation was impossible, for example, it can measure precisely, without decomposing the crack dimension of the turbine blade of the jet engine which is a curved-surface

configuration. Moreover, **** status, such as a water pipe, can also be measured precisely in un-destroying.

[0036] Moreover, you may use the thing of the wavelength which is different in semiconductor laser 62b for laser spot projection, and semiconductor laser 52a for interference fringe projection. For example, if red laser is used as semiconductor laser for blue laser and interference fringe projection as semiconductor laser for laser spot projection, from an image processing, it can range by the blue laser spot and a red interference fringe can perform 3-dimensional instrumentation automatically.

[0037] Hereafter, with reference to a drawing, the 2nd example of this invention is explained concretely.

[0038] Drawing 7 shows the cross section of an endoscope point. The 2nd example changes the ranging technique by the laser beam shown in the 1st example. It has the channel 71 which carried out opening to the endoscope point at the apical surface 70, and inserts [gage / 72] in the orientation of a nose of cam from the aforementioned channel 71.

[0039] The graduation 73 for ranging is describing on the aforementioned gage 72, and the aforementioned graduation 73 is read from B points of a visual field. It may offset beforehand and the value of B points may be describing that the aforementioned graduation 73 expresses the distance from the endoscope apical surface 70 to a body side. If (9) which sets read value to distance L and is shown in 1st example, (10), and (11) formula is used, the 3-dimensional configuration on the front face of a body can be searched for.

[0040] Since the laser spot projection unit and the light source for ranging become unnecessary according to this example, a cheaper system can be offered. In addition, it is possible for the ranging technique not to restrict to this example, to project the shadow which serves as an index together with lighting light, and to range on the basis of it. Next, the 3rd example is explained.

[0041] The 3rd example uses one laser light source into a laser light source block. Drawing 8 shows the block diagram of a laser light source 7. The outgoing-radiation light of semiconductor laser 80 branches to optical-path 83a and optical-path 83b by the beam splitter 82, after being changed into a parallel ray by the collimate lens 81. The light of optical-path 83a is condensed by the condenser lens 84 by the optical connector terminal for laser spot projection 85. The light of optical-path 83b is condensed by the condenser lens 87 through prism 86 by the optical connector terminal for interference fringe projection 88. Other configurations and operations are the same as that of the 1st example.

[0042] Heat sink 55a is attached in the aforementioned semiconductor laser 80 through the support plate 53 and the ******** element 54. Moreover, the thermistor 56 which is a temperature sensing element is attached in the aforementioned support plate 53. The temperature control of the aforementioned ******** element 54 and the thermistor 56 is carried out so that it may connect with the degree control circuit 57 of constant temperature and the aforementioned semiconductor laser 80 may be maintained at fixed temperature.

[0043] Moreover, it connects with the current control circuit 58, and the aforementioned semiconductor laser 80 is driven with a predetermined current value. The aforementioned current control circuit 58 is set to arbitrary current values by the signal of a computer 5 through the D/A-converter circuit 59. If semiconductor laser 80 changes a drive current, wavelength will shift it.

[0044] If the drive current of semiconductor laser 80 is changed by aforementioned computer 5, the phase of the interference light of the aforementioned interference fringe projection unit can shift, and the interference fringe on a body can be moved. However, even if wavelength shifts the laser spot which uses the light of the same semiconductor laser 80, the influence does not receive.

[0045] Moreover, as shown in drawing 9 (a) and (b), the movable mirror 90 may be formed in optical-path 89c, and you may make selectable optical-path 89a and optical-path 89b. In this 3rd example or its modification, a cheaper system can be offered by having constituted the light source of an interference fringe and a laser spot from one semiconductor laser 80. Next, the 4th example is explained.

[0046] The 4th example leads a laser beam to an endoscope point using one optical fiber, within an endoscope point, divides an optical path into two and uses it as light source of interference fringe irradiation optical system and laser spot illuminating system.
[0047] Drawing 10 shows arrangement of each optical system at the nose of cam of an endoscope. Drawing 11 shows the A-A cross section of drawing 10 . Drawing 12 shows the interior of a laser light source. As shown in drawing 12 , a current control and the outgoing-radiation light of the semiconductor laser 92 by which the temperature control was carried out are condensed through a collimate lens 93 and the condenser lens 94 to the fiber-optic-connector terminal 95. The light which carried out incidence from the aforementioned fiber-optic-connector terminal 95 is transmitted to an endoscope point through an optical fiber 96, as shown in drawing 11 . 2 ****s of optical paths are carried out by the back beam splitter 98 from which the laser beam transmitted to the endoscope point was changed into the parallel ray by the collimate lens 97.
[0048] The laser beam which went the aforementioned beam splitter 98 straight on goes into the interference fringe irradiation optical system 101 through optical-axis 99a, and an interference fringe is projected on a body front face through the birefringence optical member 33, the polarizing plate 34, the projection lens 35, etc. The laser beam which branched by the aforementioned beam splitter 98 changes the orientation of 90 degree, goes into the laser spot irradiation optical system 102 through an optical path, and is changed into the shaft orientations of an endoscope by prism 103, and after making it the diameter beam 106 of thin to which the beam diameter was extracted by the convex lens 104 and the concave lens 105, the outgoing radiation of it is carried out at an angle of predetermined by prism 107.
[0049] In drawing 11 , the nose of cam of a fiber 96 where plane of polarization is saved fixes to a pipe 109 with a mouthpiece 108. Moreover, the laser spot irradiation optical system 102, such as prism 103, fixes to the pipe 110. In drawing 10 , the lighting optical system 112,112 is formed in the both sides of the objective lens system 111. Other configurations are the same as that of the 3rd example.
[0050] thus, the outgoing-radiation light from one optical fiber 96 -- **** for interference fringe irradiation and laser spot irradiation -- since the amount of the expensive optical fiber 96 used is halved by things, the low cost endoscope for instrumentation can be offered
[0051] Next, the 5th example of this invention is explained concretely. The timing-chart view in which applying the drawing 13 or the drawing 18 to the 5th example of this invention, and the block diagram of a laser light source and the drawing 16 showing the block diagram of a computer, and, as for the cross section of an endoscope point and the drawing 15 , showing the driver voltage (DC-AMP output voltage) of a piezo-electric element and the timing of a frieze of each frame memory for explanatory drawing of the whole configuration of endoscope equipment and the drawing 14 , as for drawing 17 , and the drawing 18 are explanatory drawings showing change of
[0052] As shown in drawing 13 , the endoscope equipment for instrumentation 201 of the 5th example of this invention is equipped with the monitor 206 and the laser light source 207 which display the picture image from the light source for a lighting 203 and CCU204 to which the electronic endoscope 202 and this electronic endoscope 202 for instrumentation are connected, the computer 205 connected to aforementioned CCU204, and the computer 205.
[0053] It can detach [connector / light source / 214 / which was prepared at the nose of cam of the universal cable 213 which the above-mentioned electronic endoscope 202 has the insertion section 211 of ** length, and the control unit 212 of **** formed successively by the back end of this insertion section 211, and extended outside from this control unit 212] freely to the light source for a lighting 203, and can equip. A signal cable 215 and the optical cable 216 can extend from this connector 214, and the connectors 217 and 218 prepared in each edge can be connected to CCU204 and the laser light source 207, respectively.
[0054] The hard point 219 is formed at the nose of cam, the insertion section 211 of the above-mentioned electronic endoscope 202 adjoins this point 219, the bend 221 which can curve freely is formed, and the long elasticity section 222 is further formed in the back end of this bend 221. The above-mentioned bend 221 can curve now by operating the curve knob

223.prepared in the control unit 212. The above-mentioned computer 205 is connected with the keyboard 224.

[0055] Drawing 14 shows the cross section of the point 219 of the electronic endoscope 202. The laser spot projection unit 228 for making the luminescent spot is formed in interference fringe lighting within the limits of the image pck-up unit 226 for acquiring the light-guide fiber not to illustrate, the lighting lens section, and the picture image for illuminating an inspected object in the point 219 of the electronic endoscope 202, the interference fringe projection unit 227 which projects an interference fringe on a body side, and a body side. The above-mentioned image pck-up unit 226 has the solid state image pickup device 230 and the signal cable 231 for changing into an electrical signal the optical image which carried out image formation by the objective lens system 229 and the objective lens system 229.

[0056] The collimate lens 234 with which the above-mentioned interference fringe projection unit 227 makes parallel light injection light of this single mode fiber 232 to which the nose of cam was fixed with the single mode fiber 232 and the mouthpiece 233, The polarization beam splitter 235 separated and outputted to the light of two polarization components which intersect perpendicularly mutually from this parallel light, The projection lens 236 which projects the light which passed through this polarization beam splitter 235, It has the piezo-electric element 239 for making the variation rate of the mirrors 237 and 238 for giving the optical path difference for the light of aforementioned one polarization component to the light of the polarization component of another side, and one mirror 237 carry out in the orientation perpendicular [237th page of this mirror].

[0057] The piezo-electric element 239 attached in reflector 237a formed by the vacuum evaporationo formed in the rear face of the above-mentioned projection lens 236, the mirror 238, and the mirror 237 is attached in the point 219 through the electrode holder 241. In addition, reflector 238a is formed also in the rear face of a mirror 238 by vacuum evaporationo etc. The two above-mentioned mirrors 237 and 238 are arranged at the vertical both sides of a polarization beam splitter 235, a mirror 237 is distance(for example, referred to as M)-separated from a polarization beam splitter 235, and is arranged, and the mirror 238 of another side is arranged in contact with the top of a polarization beam splitter 235, for example, the thickness is N.

[0058] An electrode is attached in both sides of the above-mentioned piezo-electric element 239, to each electrode, it connects with the nose of cam of lead wire 242, a piezo-electric element 239 is driven from the drive circuit not to illustrate, and the variation rate of the position of a mirror 237 is carried out in the vertical orientation.

[0059] The optical component which the parallel light which passed through the above-mentioned collimate lens 234 penetrates a polarization beam splitter 235, and progresses along with optical-path A, It is reflected by the polarization beam splitter 235, and is reflected by the 1st mirror 237. Penetrate a polarization beam splitter 235 and it is reflected by the 2nd mirror 238. The light which progresses along with optical-path B to the light which is divided into the optical component which is furthermore reflected by the polarization beam splitter 235, and progresses like optical-path B, and progresses along with optical-path A If thickness (length) of the vertical orientation of a polarization beam splitter 235 is set to L After giving optical-path-length (optical path difference) D only with 2 [large] (rL+sM+N) (r and s are the refractive index of a polarization beam splitter 235 and the mirror 238), it is projected on a photographic subject (body side) side through both the projection lenses 236.

[0060] And an interference fringe which was shown in drawing 3 according to optical-path-difference D will be formed in a photographic subject side, the above-mentioned piezo-electric element 239 is driven further, and the variation rate only of the minute optical-path-difference delta D is carried out from this optical-path-difference D by making the variation rate of the position of a mirror 237 carry out in the vertical orientation. An interference fringe shifts and it enables it to search for the 3-dimensional configuration of a body side by the 4 bucket method by carrying out the variation rate only of this minute optical-path-difference delta D.

[0061] The above-mentioned laser spot projection unit 228 has the prism 246 for carrying out

the outgoing radiation of the convex lens 245 which changes the outgoing-radiation light from the optical fiber 244 and the optical fiber 244 into the predetermined diameter of the flux of light, and the aforementioned flux of light at an angle of predetermined. The nose of cam of the above-mentioned optical fiber 244 fixes to a pipe 248 through a mouthpiece 247, and this pipe 248 is fixed to a point 219.

[0062] Drawing 15 shows the block diagram of a laser light source 207. The outgoing-radiation light of semiconductor laser 80 branches to optical-path 83a and optical-path 83b by the beam splitter 82, after being changed into a parallel ray by the collimate lens 81. The light of optical-path 83a is condensed by the condenser lens 84 by the optical connector terminal for laser spot projection 85. Moreover, semiconductor laser 80 is driven by the constant-current control circuit 258. This constant-current control circuit 258 is controlled by the computer 205 through the D/A-converter circuit 59, and maintains an interference fringe at the suitable quantity of light. Other configurations are the same as that of the laser light source 7 of the 3rd example shown in drawing 8 .

[0063] On the other hand, the internal configuration of the above-mentioned computer 205 is shown in drawing 16 . The picture signal from above-mentioned CCU204 is inputted into the frame memories A, B, C, and D which constitute the frame memory section 251, and can be frozen to arbitrary timing with the signal from CPU of (the CPU& memory 252). Moreover, the variation rate of the piezo-electric element 239 included in the interference fringe projection unit 227 of the endoscope point 219 is controlled by the voltage by CPU through D/A converter 253 and DC-AMP254.

[0064] That is, by controlling the variation rate of a piezo-electric element 239 from a computer 205, optical-path-difference D to minute optical-path-difference deltaD of the above-mentioned optical-path A and optical-path B is changed, and the phase of an interference fringe can be set up arbitrarily. And the result of an operation by CPU is displayed on a monitor 206 through the graphic board 255.

[0065] The driver voltage to the above-mentioned piezo-electric element 239 and the timing of a frieze of frame memories A, B, C, and D are shown in drawing 17 . The output voltage of DC-AMP254 impressed to a piezo-electric element 239 as shown in this drawing 17 is Phase as it is shown in drawing 18 so that it may be made to change stair-like and the phase (Phase) of the interference fringe projected on a body side may change every 90 degrees that is,. A, B, C, and D determine that the output voltage of DC-AMP254 will change every 90 degrees.

[0066] Moreover, it is made to generate the frieze signal which memorizes a frieze picture image to frame memories A, B, C, and D, respectively as shown in drawing 16 where the Gentlemen phase of the interference fringe projected on a body side is stabilized. Thus, the driver voltage to a piezo-electric element 239 is changed in the shape of a phase, the phase of the interference fringe on a body side is changed every 90 degrees, the picture image for every Gentlemen phase is incorporated to the four sheet frame memories A, B, C, and D, and a solid configuration is searched for by performing data processing by CPU. This operation technique is the same as that of the 1st example. In addition, you may use actuators, such as SMA, instead of the piezo-electric element 239 of this example.

[Translation done.]

DESCRIPTION OF DRAWINGS

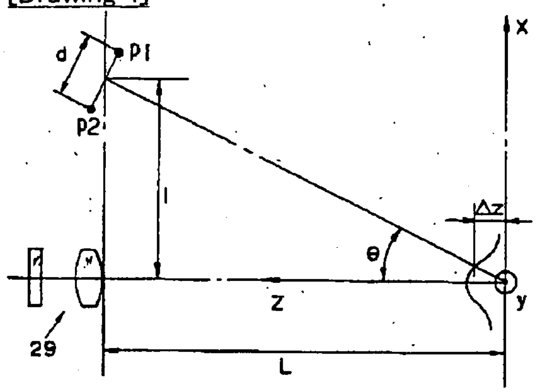
[Brief Description of the Drawings]
[Drawing 1] The whole endoscope equipment block diagram for instrumentation of the 1st example of this invention.
[Drawing 2] The cross section of an endoscope point.
[Drawing 3] The schematic diagram of 3-dimensional instrumentation.
[Drawing 4] The principle view of the instrumentation by the interference fringe.
[Drawing 5] The principle view of the ranging technique by the laser spot.
[Drawing 6] The block diagram of a laser light source.
[Drawing 7] The cross section of an endoscope point in the 2nd example of this invention.
[Drawing 8] The block diagram of the laser light source in the 3rd example of this invention.
[Drawing 9] The block diagram of a part of laser light source in the modification of the 3rd example.
[Drawing 10] Front view showing arrangement of each optical system at the nose of cam of an endoscope in the 4th example of this invention.
[Drawing 11] The cross section showing the A-A cross section of drawing 10 .
[Drawing 12] The block diagram showing the interior of the laser light source in the 4th example.
[Drawing 13] The whole endoscope equipment block diagram for instrumentation of the 5th example of this invention.
[Drawing 14] The cross section of an endoscope point in the 5th example.
[Drawing 15] The block diagram of a laser light source.
[Drawing 16] The block diagram of a computer.
[Drawing 17] Explanatory drawing showing the driver voltage to a piezo-electric element, and the timing of the frieze to four frame memories.
[Drawing 18] Explanatory drawing showing the relation of four phases of the interference fringe projected on a body side.
[Description of Notations]
1 -- Endoscope equipment for instrumentation
2 -- Electronic endoscope
3 -- The light source for a lighting
4 -- CCU
5 -- Computer
6 -- Monitor
7 -- Laser light source
11 -- Insertion section
19 -- Point
26 -- Image pck-up unit
27 -- Interference fringe projection unit
28 -- Laser spot projection unit
29 -- Objective lens system
30 -- Solid state image pickup device
32 -- Plane-of-polarization store fiber

33 — Birefringence optical member
34 — Polarizing plate
35 — Projection lens
41 — Optical fiber
42 — Convex lens
43 — Prism

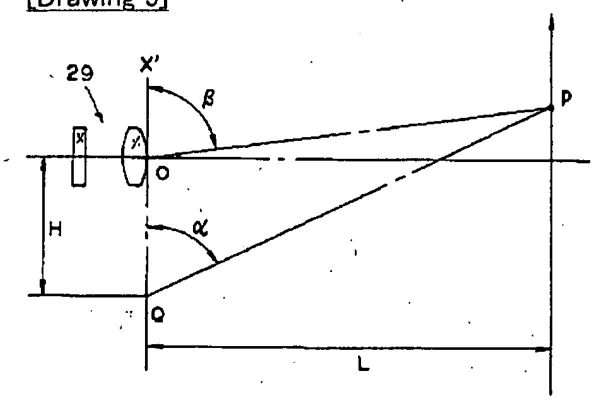
[Translation done.]

DRAWINGS

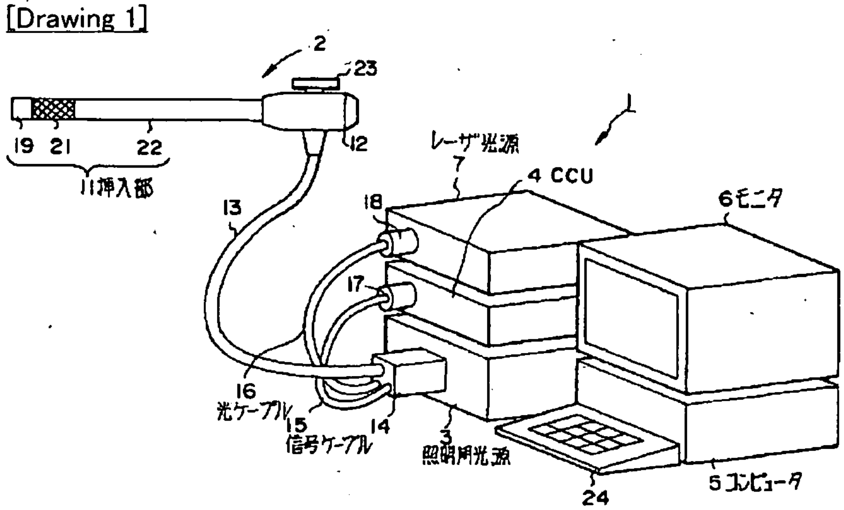
[Drawing 4]



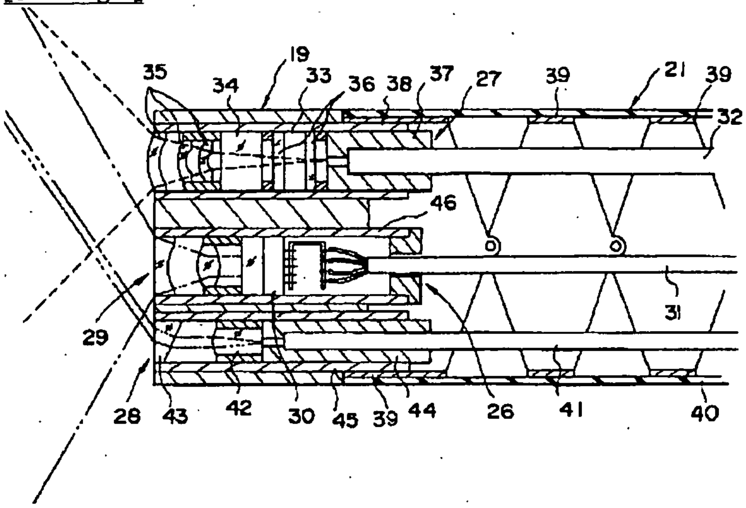
[Drawing 5]



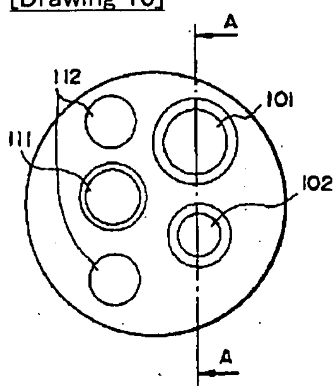
[Drawing 1]



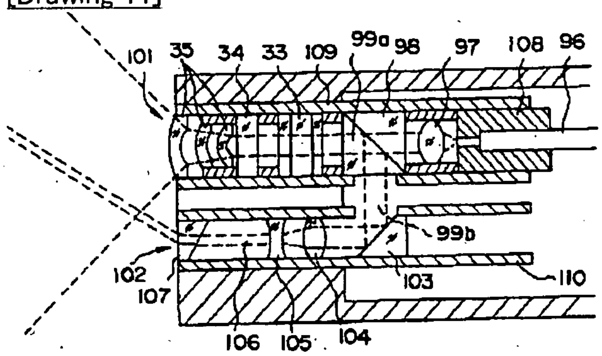
[Drawing 2]



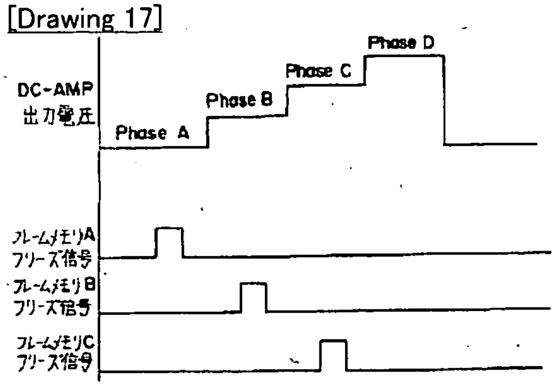
[Drawing 10]

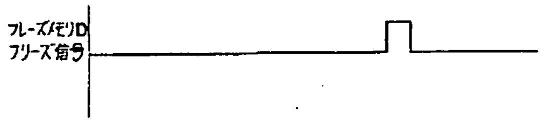


[Drawing 11]

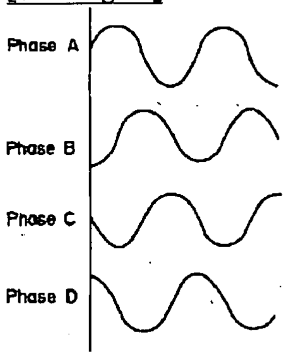


[Drawing 17]

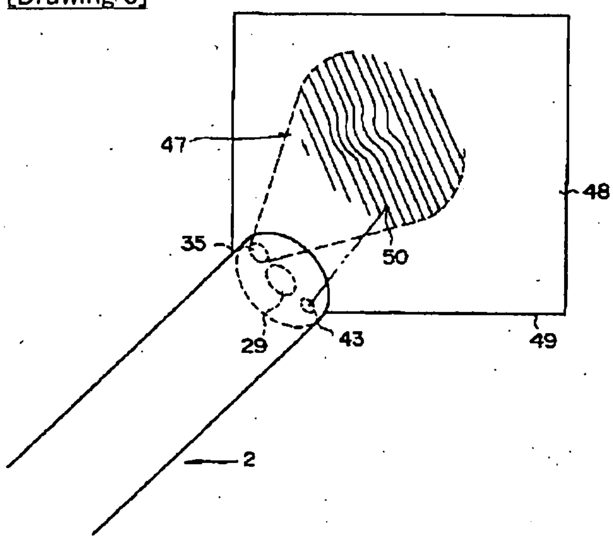




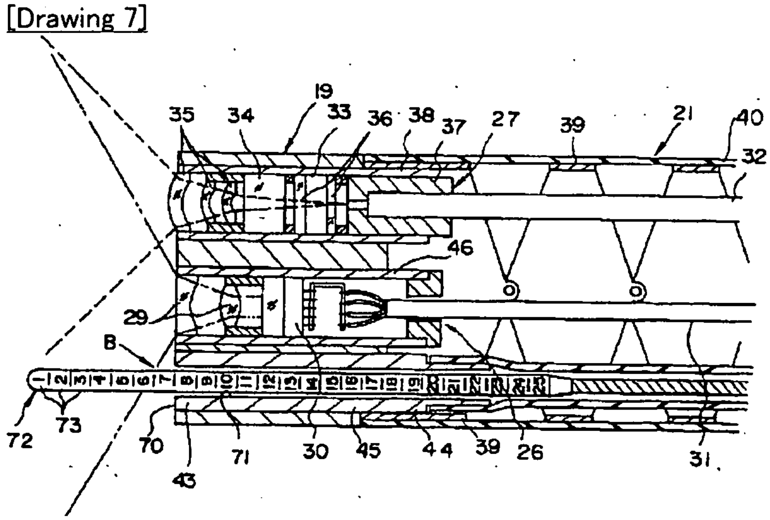
[Drawing 18]



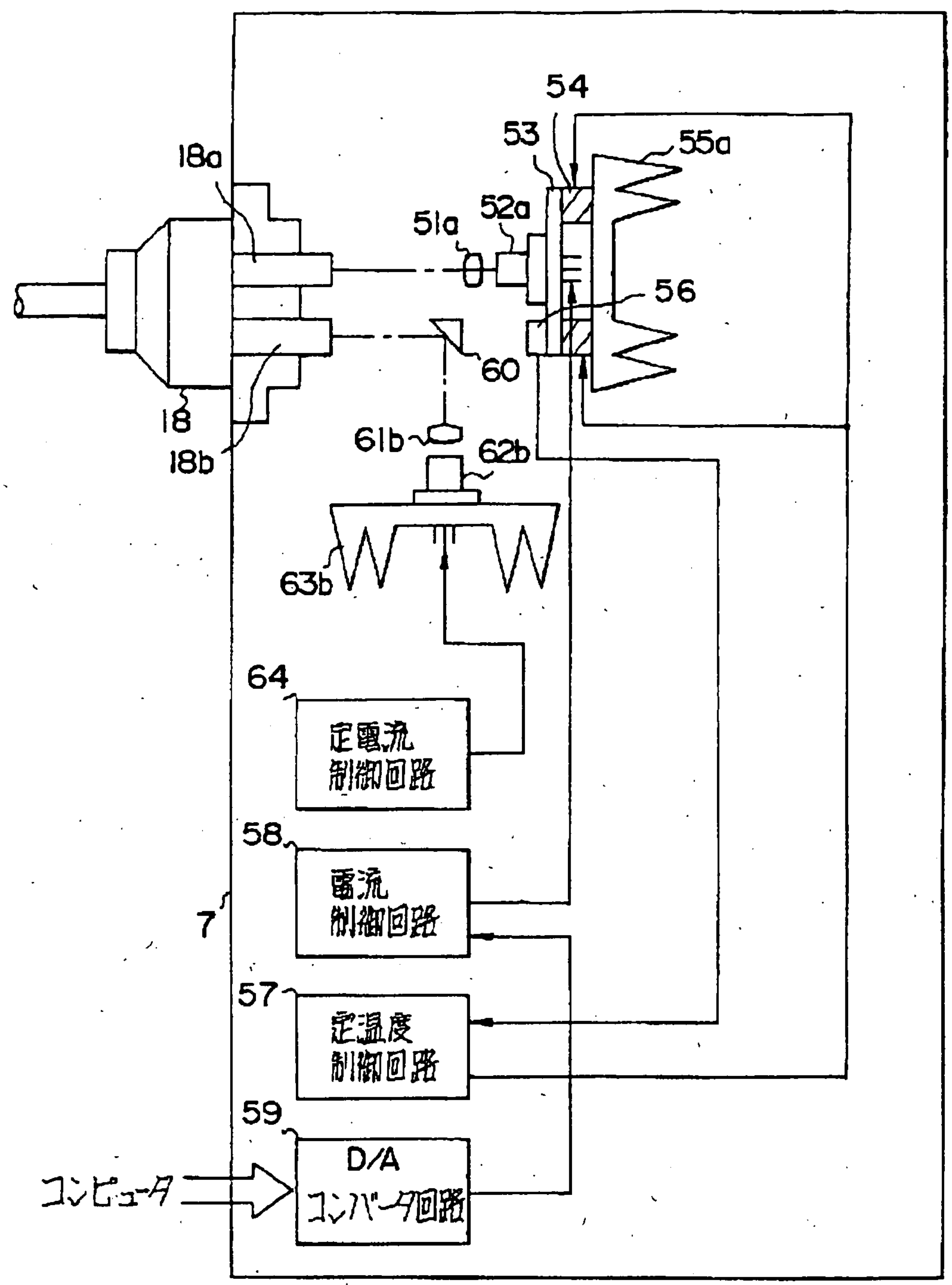
[Drawing 3]



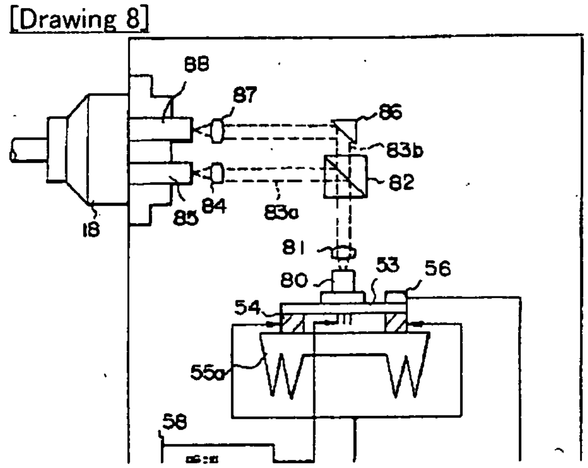
[Drawing 7]



[Drawing 6]


54
53
55a
18a
52a
51a
56
60
18
61b
62b
18b
63b
64
定電流
制御回路
58
電流
制御回路
7
57
定温度
制御回路
59
D/A
コンバータ回路
コンピュータ

[Drawing 8]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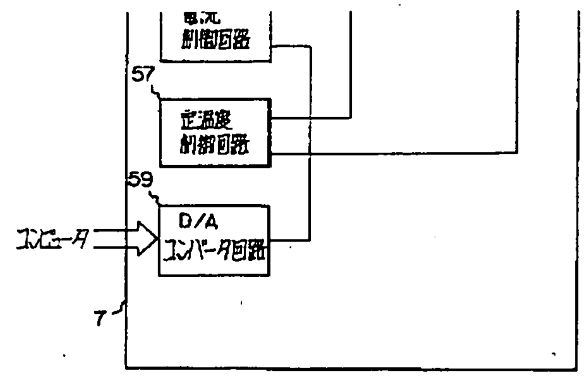
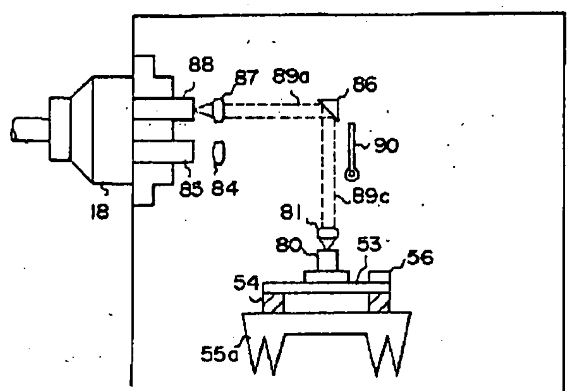
87
86
83b
82
84
85
83a
18
81
80
53
56
54
55a
58

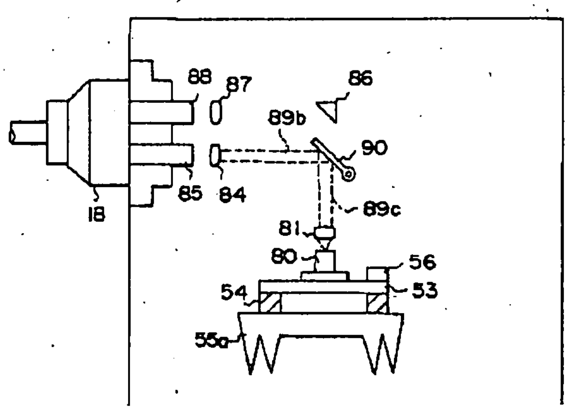


[Drawing 9]

(a)

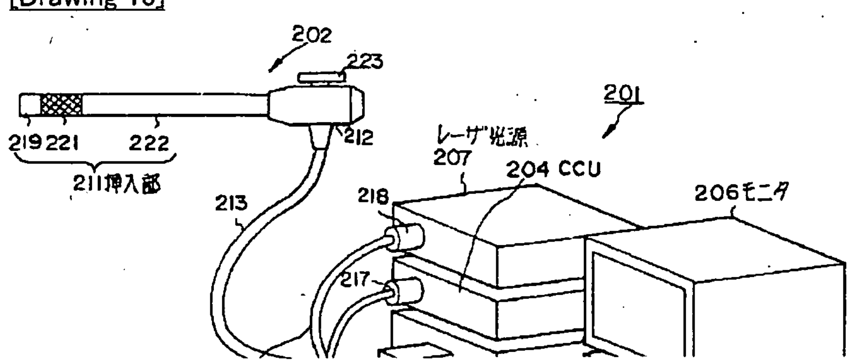


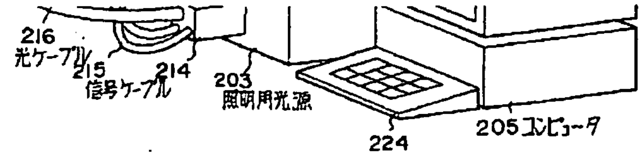
(b)



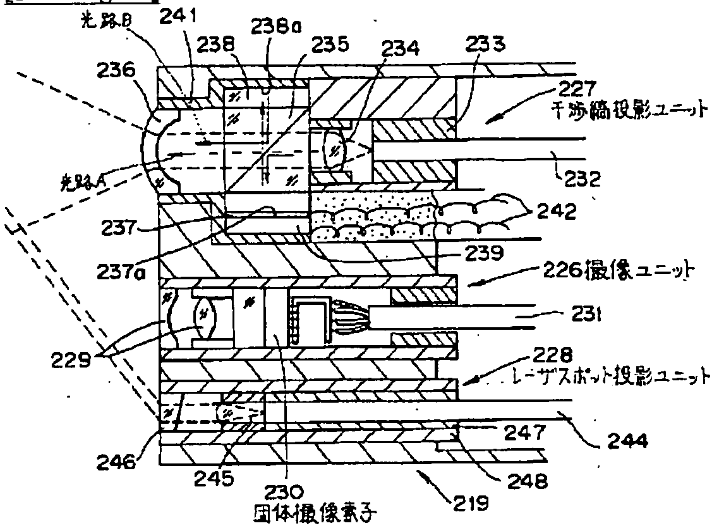
[Drawing 12]

[Drawing 13]

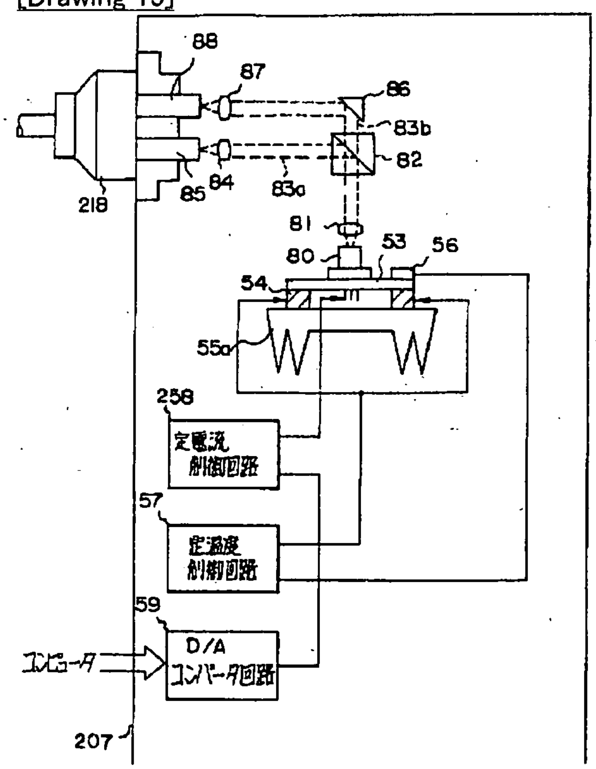




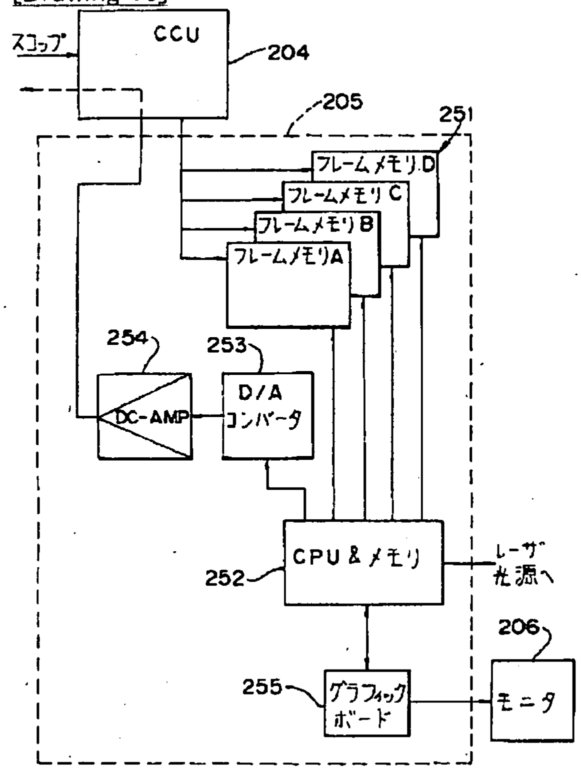
[Drawing 14]



[Drawing 15]



[Drawing 16]



[Translation done.]